Faculty of Arts
University of Helsinki
Finland

User Stories of Erkki Kurenniemi's Electronic Musical Instruments, 1961–1978

Mikko Ojanen

DOCTORAL DISSERTATION

Doctoral dissertation to be presented for public discussion
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in Porthania III, on the 18th of December 2020 at 16 o'clock.

Helsinki 2020

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I wrote this dissertation as a PhD Candidate in the Doctoral Programme for Philosophy, Arts and Society / Musicology / University of Helsinki and in the Finnish Doctoral Programme for Music Research

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Language reviser: Joan Nordlund, MA.
Layout: Mikko Ojanen
Printed by Unigrafia, Helsinki 2020

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1st Edition – version: 20201127_01

Cataloguing-in-Publication Data

Ojanen, Mikko, 1974- author, respondent.
User stories of Erkki Kurenniemi's electronic musical instruments, 1961-1978 / Mikko Ojanen. – Helsinki, 2020 (Helsinki : Unigrafia, 2020). – xxvi, 293 pages : illustrations ; 25 cm
Thesis (Ph.D.) – University of Helsinki, 2020.
Includes bibliographical references (pages 257-290)
URN: http://urn.fi/URN:ISBN:978-951-51-6394-3
DOI: https://doi.org/10.5281/zenodo.4018719
ISBN 978-951-51-6393-6 (paperback)
ISBN 978-951-51-6394-3 (PDF)
1. Synthesizer (Musical instrument)—Scandinavia—History—20th century. 2. Synthesizer (Musical instrument)—Construction. 3. Synthesizer music—Scandinavia—20th century—History and criticism. 4. Music and technology—History—20th century. 5. Kurenniemi, Erkki, 1941-2017.
GAC: e-fi--- e-sw---
DDC/23: 786.7/419
LCC: ML1092 .O33 2020
UDC: 780.653.36"1961/1978"(480+485)(091)(043)=111
YKL: 64.5409; 78.8809

Abstract

The focus in this study is on electroacoustic music and the design of electronic musical instruments in Finland during 1961–1978, approached from both a historical and an analytical perspective. There are three main threads: *music history* (the historical and cultural context in the Nordic countries in the 1960s and 1970s), *music technology* (the design and use of electronic musical instruments), and *electroacoustic music* (aesthetics and musical analysis). The study belongs to the domain of music technology research and the scientific stance is interdisciplinary. On the one hand, I employ music analysis and the concepts of the modern historiographical paradigm, ethnography and aesthetics theory in my analysis and description of the cultural and historical context of electroacoustic music. On the other hand, I adopt concepts from Science and Technology Studies (STS) in describing the technological developments and social networks.

At the core of the study are the musical instruments and music of the Finnish instrument designer and composer Erkki Kurenniemi (1941–2017). At the time when technology dedicated to electronic music production was practically nonexistent and studios accommodating the genre were rare, and expensive to set up, Kurenniemi's designs enabled and facilitated the work of several composers. In addition to his Finnish collaborators, he worked with many Nordic composers and artists. His visionary ideas and technical expertise were influenced by the works of many of his contemporaries – and vice versa. Kurenniemi's work serves here as a lens through which I observe the broader picture of the cultural and historical circumstances of electroacoustic music – even beyond the Finnish scene. Instead of concentrating on the canonical works and central actors in the field, I focus on the small Helsinki-based community, which had active links to Sweden and Norway as well as frequent connections with Central European studios. The study sheds light on these less commonly studied social connections.

Beyond the temporal and the geographical, the works of Kurenniemi and his Nordic collaborators provide overarching perspectives on the interaction between music and technology. For example, static and detailed descriptions of musical instruments do not suffice to depict the impact of technological development on musical aesthetics. To study this aspect further, I examine Kurenniemi's instruments in the hands of their users. In analyzing the use of his instruments, I show how technological artifacts develop in complex interaction between the original designer, the users, and the artifact itself rather than in an isolated laboratory with a lonely designer.

Kurenniemi's own musical output, on the other hand, provides an example of a music-production process in which the works are created in close – and often real-time – interaction with the production technology. In extreme cases, the role of the technology is strongly emphasized and could even be the

most influential factor in the music-making. This type of technology-driven music production and composition process challenges the traditional concept of a musical work, questions the typical intentions of a composer, and anticipates many production methods that have emerged, especially in experimental productions and popular music.

Tiivistelmä

Väitöstutkimuksessani tarkastelen elektroakustisen musiikin historiaa sekä sähkösoitinsuunnittelua Suomessa vuosina 1961–1978. Tutkimukseni kolme pääteemaa ovat *musiikinhistoria* (historiallinen ja kulttuurinen konteksti Pohjoismaissa 1960–70-luvuilla), *musiikkiteknologia* (elektronisten soitinten suunnittelu ja käyttö) ja *elektroakustinen musiikki* (estetiikka ja musiikkianalyysi). Työni kuuluu musiikkiteknologian tutkimuksen alaan, ja se muodostuu monitieteisistä tutkimusteemoista. Elektronisen musiikin kulttuurihistorian kuvaukseen ja analyysiin sovellan modernin historiankirjoituksen, etnografian ja esteettisen teorian käsitteitä sekä musiikkianalyysiä. Sosiaalisten verkostojen ja teknologian kehityksen hahmottamiseen hyödynnän tieteen ja teknologian tutkimuksessa (Science and Technology Studies, STS) kehitettyjä teorioita ja käsitteitä.

Työni keskeinen toimija on soitinsuunnittelija ja säveltäjä Erkki Kurenniemi (1941–2017). Kurenniemen soittimet mahdollistivat elektronisen musiikin tuottamisen Suomessa aikana, jolloin kyseisen musiikkityylin toteuttamiseen soveltuvat studiot olivat harvinaisia ja teknologia kallista. Suomalaisten yhteistyökumppaneidensa lisäksi Kurenniemi työskenteli myös monien pohjoismaisten säveltäjien ja taiteilijoiden kanssa. Hänen visionäärinen ideointinsa ja tekninen asiantuntemuksensa vaikutti monien hänen aikalaistensa töihin – ja päinvastoin. Kurenniemen työ musiikkiteknologian parissa toimii tutkimukseni lähtökohtana ja linssinä, jonka kautta tarkastelen pohjoismaisen elektronisen ja kokeellisen musiikin kulttuurihistoriallista tilannetta sekä usean säveltäjän ja avantgardetaiteilijan töitä. Kanonisoitujen teosten ja elektroakustisen musiikin keskeisten toimijoiden tarkastelun sijaan tutkimukseni painopiste on helsinkiläisessä pienessä yhteisössä, jolla oli aktiiviset yhteydet Ruotsiin ja Norjaan sekä jopa Keski-Euroopan studioihin. Tutkimukseni yhdeksi keskeiseksi teemaksi muodostuu historiallisten toimijoiden sosiaalisen verkoston ja yhteistyön kuvaaminen.

Työni ajallisen ja maantieteellisen rajauksen ohella Kurenniemen ja hänen yhteistyökumppaneidensa tuottama musiikki ja kokeellinen taide luovat pohjan myös musiikin ja teknologian vuorovaikutuksen yleisemmälle tarkastelulle. Soitinten staattinen ja yksityiskohtainen kuvailu ei yksinään riitä musiikin teknisen kehityksen ja musiikin esteettisen muutoksen vuorovaikutuksen analysointiin. Tutkiakseni tätä muutosta tarkemmin tarkastelen Kurenniemen soittimia erityisesti niiden käyttöyhteyksissä. Analysoimalla Kurenniemen instrumenttien käyttöä osoitan, kuinka teknologiset artefaktit kehittyvät pikemminkin alkuperäisen suunnittelijan, käyttäjien ja itse artefaktin välisessä monimutkaisessa vuorovaikutuksessa kuin yksinäisen suunnittelijan keksintöinä, muusta maailmasta eristetyssä laboratoriossa. Kurenniemen oma taiteellinen tuotanto tarjoaa esimerkin musiikin tuotantoprosessista, jossa teokset luodaan tiiviissä – usein reaaliaikaisessa – vuorovaikutuksessa

tuotantoteknologian kanssa, mikä on tyypillistä elektroakustisen ja kokeellisen musiikin kontekstissa. Äärimmäisessä tapauksessa teknologian rooli korostuu jopa siinä määrin, että siitä muodostuu tärkein musiikin tekemistä ohjaava tekijä. Tällainen musiikintuotantoprosessin muoto haastaa laajentamaan perinteistä taideteoksen määritelmää sekä kyseenalaistaa säveltäjän intention luomisprosessin osana.

List of abbreviations and acronyms

ANT	Actor Network Theory (a theoretical frame)
DIMI [w/suffix]	The brand name of Kurenniemi's DEF period DIgital Musical Instruments
DMI	Digital musical instrument (a generic term for modern digital music instruments)
DEF	Digelius Electronics Finland (a company)
DN	*Dagens Nyheter* (a newspaper)
EMS	Elektronmusikstudion (EMS), Stockholm
ESS	*Etelä-Suomen Sanomat* (a newspaper)
FNG/EKA	Finnish National Gallery, Erkki Kurenniemi Archive
Hbl	*Hufvudstadsbladet* (a newspaper)
HS	*Helsingin Sanomat* (a newspaper)
HYY	The Student Union of the University of Helsinki
IS	*Iltasanomat* (a tabloid)
KAVI	The National Audiovisual Institute, Helsinki
KU	*Kansan Uutiset* (a newspaper)
LTS	Large Technological Systems (a theoretical frame)
UHMRL	The University of Helsinki Music Research Laboratory
SCOT	Social Construction of Technology (a theoretical frame)
STS	Science and Technology Studies (a theoretical frame)
TeaMA	Theater Museum archive, Helsinki
Yle	The Finnish Broadcasting Company, Helsinki

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Note on previously published articles

A few sections of this dissertation are based on my previous publications, but I have re-written them for this context.

Chapter 4.2 and some of the descriptions of musical works in Chapter 7, recycled:

Ojanen, Mikko. 2014. Electroacoustic concert and happening performances of the ’60s and early ’70s in Finland. In *EMS Proceedings and Other Publications: EMS14 - Electroacoustic Music Beyond Concert Performance* (pp. 1–13). Berlin: Electroacoustic Music Studies Network.

Chapter 5 is based on our co-written articles:

Ojanen, Mikko, & Suominen, Jari. 2005. Erkki Kurenniemen sähkösoittimet. *Musiikki*, 35(3), 15–44.

Ojanen, Mikko, Suominen, Jari, Kallio, Titti, & Lassfolk, Kai. 2007. Design principles and user interfaces of Erkki Kurenniemi’s electronic musical instruments of the 1960’s and 1970’s. In *Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07)*, New York, NY, USA (pp. 88–93). New York: Harvestworks.
https://doi.org/10.1145/1279740.1279756

The background of the Finnish studios (Chapter 4) and the history of the University Studio (Chapter 5) are based on my article:

Ojanen, Mikko. 2013. Erkki Kurenniemi’s electronic music studio. In M. Mellais (Ed.), *Erkki Kurenniemi: a Man From The Future* (pp. 99–128). (Kuvataiteen keskusarkisto / Central Art Archives; No. 25). Helsinki: Valtion taidemuseo, Kuvataiteen keskusarkisto.
https://doi.org/10.5281/zenodo.804969

Part of the analysis of Kurenniemi’s *Inventio* (Chapter 7) is published in:

Lassfolk, Kai, Suominen, Jari, & Ojanen, Mikko. 2015. Interaction of Music and Technology: The Music and Musical Instruments of Erkki Kurenniemi. In J. Krysa, & J. Parikka (Eds.), *Writing and Unwriting (Media) Art History: Erkki Kurenniemi in 2048* (pp. 261–277). (Leonardo Book Series). Cambridge, Mass.: MIT Press.

Contents

Preface and acknowledgements

I started working at the library of the Department of Phonetics of the University of Helsinki, in its Vironkatu premises, on October 1, 1996. I soon realized that the building had something to do with the legendary Finnish electronic musical instrument designer Erkki Kurenniemi. I knew Kurenniemi's name and the fascinating sounds of his Andromatic synthesizer from the early 1990s CD reissue of *Tombstone Valentine*, the second album of the Finnish progressive pop group Wigwam released originally on an LP vinyl record in 1970, on which an excerpt of Kurenniemi's *Antropoidien tanssi* was released. I recall being quite excited when I gradually realized that I was put to work in the very same building in which significant steps in the history of Finnish electronic and experimental music had been taken.

Obviously, I had no idea about any of the stories the very rooms in which I was working had witnessed some 30 years earlier. Fortunately, an article and a Master's thesis written by Kalev Tiits in the next-door musicology library collection revealed many interesting details of those stories, and history started to unwrap itself slowly. It was so slow, in fact, that I realized only a few months ago that the door opposite my first desk in the library was the one that separated Kurenniemi's small workspace from the office of the Department of Musicology in the late 1960s. I found this out during an interview with composer Jukka Ruohomäki, who was Kurenniemi's closest collaborator in Vironkatu in the early 1970s. Several other details are yet to be revealed, and stories to be told.

During the following years, and at an accelerating pace, I paid many a visit to the musicology studio, which was relocated after the large-scale renovation in the early 1980s to the other side of the building, half a floor down from where I was working. By 2000, I had browsed the several cellars of the department and, among other things, found a few tape reels with sounds from Kurenniemi's instruments he had recorded sometime in the early 1970s. At the time the studio was occupied by the three-piece analog synthesizer group Nu Science, which I had together with Henri Tani and Aku Raski. Copying the idea from the 30-year-old Wigwam album, I wanted to include a snippet of Kurenniemi's sounds on our record. I contacted Kurenniemi in November 2000 to ask for his permission. He did not remember what the sounds were, but he was happy to agree. So, I edited a short fragment of Kurenniemi's sounds as an introduction to our track *Tripodien aika*. In return, he requested a copy of our album.

A couple of Kurenniemi's instruments were stored in the cellar among the tapes. Pauli Laine and Kai Lassfolk, who took care of the studio starting from the 1980s, were kind enough to let me take a peculiar box, which turned out to be the DIMI-A, up to the studio to try it out. Previous attempts had failed over the years. The lights were blinking but there was no sound. One evening, after work, I stayed in the studio and patiently tapped the metal plates with two styluses for a couple of hours, following the DIMI-A "user manual". At the time I did not understand how or why, but with a certain combination of selected parameters and their values, the distinctive square wave sound appeared. My mind was blown. I immediately rang Kai, who was probably ready to go to bed so late in the evening. The news that the DIMI-A was working again after some 20 years of silence had to be shared with Kurenniemi: he visited the studio shortly afterwards. This was the first time I met him in person.

Meanwhile, media artist and musicologist Petri Kuljuntausta had finished his book about the early phases of electronic music in Finland. He had heard from Kurenniemi that the DIMI-A had been recovered. To celebrate the publication of his book *On/Off*, Kuljuntausta organized a party and asked Kurenniemi to perform. Thinking that he might not know how to use the instrument, Kurenniemi suggested we demonstrate it together. The DIMI-A was heard for the first time in public after an almost 30-year hiatus on June 5, 2002. Years later, I learned that the performance setup was similar to the one on November 17, 1970 when Kurenniemi introduced the DIMI-A to the public – with Ruohomäki performing. A couple of weeks after our DIMI-A performance, film director Mika Taanila contacted me and asked if I was interested in participating in the Avanto festival the following November.

At the time, Taanila was filming a documentary about Kurenniemi entitled *Tulevaisuus ei ole entisensä* (Engl. The Future is Not What It Used To Be), and compiling a CD record of his musical works. Among these releases, Taanila was organizing an event to honor Kurenniemi's work as part of the Avanto festival. Eventually, the *Homage to Erkki Kurenniemi* was given on November 21, 2002, in the Kiasma Theater. It consisted of the premiere of Taanila's documentary, our remake of Kurenniemi's *Deal* (1971/72) for the DIMI-O video synthesizer together with dancer Topi Tateishi, aerial artist Ilona Jäntti, Kurenniemi and me, and a performance by Mika Vainio and Ilpo Väisänen from Pan Sonic, Carl Michael von Hausswolff and Kurenniemi with Kurenniemi's instruments restored by Jari Lehtinen. Another event in the festival program presented a performance by the original line-up of Sähkökvartetti with M.A. Numminen, Tommi Parko, Arto Koskinen and Peter Widén – this was and remains the only performance by the original line-up since 1970. Sähkökvartetti is a collective electronic musical instrument commissioned by Numminen from Kurenniemi in 1968.

The instruments (the Andromatic, the DIMI-O and the DIMI-S) loaned from Swedish composer Ralph Lundsten were returned to his Andromeda Studio in Stockholm after the festival, and those that remained in Finland were added to the University Studio collection, where they have frequently been used in teaching, training, and performances over the years. The year 2002 clearly marked a watershed and a revival of Kurenniemi's instruments. During the following years Kurenniemi, Pan Sonic and von Hausswolff performed in key European biennales, while Kurenniemi and I performed in local events together with Jari Suominen.

In 2003, Susanna Välimäki asked me to write an article for a theme issue on music and technology in the musicological journal *Musiikki*. This request triggered a string of events, which led to this PhD dissertation – eventually. Suominen, a distinguished media artist and instrument designer-to-be, started as a student at the University Studio some time in the early 2000s. He was seemingly enthusiastic about Kurenniemi's designs and deeply technologically oriented. In order to strengthen the technical side of the project I thought that he would be an excellent collaborator in its completion, so I asked him to co-write the article with me. Suominen, Lassfolk and I soon formed the Kurenniemi research group, and our cooperation has continued ever since.

Amid the concerts and performances Kurenniemi's instruments were frequently displayed at exhibitions, which together with Kurenniemi's archival activities were organized by Perttu Rastas and Maritta Mellais from the Finnish National Gallery (FNG). Mainly due to Rastas's efforts, Kurenniemi's private collection was deposited in the FNG in 2006, where his legacy remains at the disposal of researchers. Rastas's initiatives also led to the acquisition of a couple of Kurenniemi's instruments for the collections of responsible organizations. Our international collaboration with Kurenniemi's archive research reached its peak in a series of exhibitions in the early 2010s, mainly on the initiative of the FNG, Kiasma and Rastas. Two years of intensive research and production with the international curation team led to the exhibitions in Documenta13 in Kassel in 2012, Kunsthal Århus in 2013, and Kiasma, Helsinki in 2013–14. In 2015, the collaboration spawned the MIT Press anthology *Writing and Unwriting (Media) Art History: Erkki Kurenniemi in 2048*, edited by Joasia Krysa and Jussi Parikka with a significant contribution by our Kurenniemi research group among many distinguished researchers. We formed a quartet for the exhibition tour, DIMIs Re-connected, with Lebanese-French sound artist Tarek Atoui, Lassfolk, Suominen, and me. Since then we have frequently performed as the DIMI Trio – with various combinations of Lassfolk, Suominen, Maiju Jouppi, and me.

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Joanna Demers writes in *Listening through the noise* (2010) that "aesthetics is a dirty word in some parts of academia". Over the years, I have observed that academia is a dirty word among some practitioners whose goal is to get the work done and not to ponder on theoretical or conceptual details. The superb technical expertise of Suominen as well as his hands-on experience in instrument design has made me understand the significance of interdisciplinary approaches. Our collaboration with him and Lassfolk shows that art studies, social sciences and humanities (SSH), engineering practices and artistic research could greatly benefit from each other. Only by bringing people with different backgrounds together can we produce genuinely new knowledge and understanding of our surrounding environment. This has been my main motivation during this PhD project.

My motivation was strengthened even further when I started to work in Data Support at Helsinki University Library in January 2016. Our work in training and consulting researchers on research data management (RDM) issues is closely related to the open science and research (OSR) initiative. My five years of trying to match this PhD project with OSR principles have taught me a great deal about my own research, as well as how little we still know about the implementation of RDM and OSR challenges in the social sciences and humanities. I took OSR principles seriously. I learned that open science requires significant planning in advance and a considerable amount of dedicated resources – both time and money. OSR principles cannot be added to a project, they should guide research projects on all levels – from daily workflows on the concrete grassroots level to the ideological approach of the researcher. The sacrifice of time and money pays off, however. In the near future we will see how researchers earn credit for their choices in supporting openness – and most importantly, OSR will help to make research processes and outcomes more transparent, ethical and reusable. They reinforce the impact of our work on society.

The general requirement according which a PhD dissertation must be based on the work of an individual researcher is absurd. We spend hours carving our independent position in relation to the works of others, which eventually is an impossible task. Instead, we should consider how we learn to conduct research together as a community supporting each other and sharing our thoughts and visions. This is what OSR is all about. To state that the following 300 pages are based on painstaking work by me as an individual, an independent doctoral candidate, is a preposterous fallacy. A work of this scale cannot be completed by a single person. Therefore, acknowledgements are in place.

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First and foremost, I have to say that the most exciting and utterly irreplaceable part of this project has been the chance to talk to the people who were there when the events that are chronicled took place. My deepest gratitude goes to all the research participants who, without any hesitation, were willing to talk with me, share their memories and even open their archives. Many thanks to all of you! Your wonderful work, the cultural historical legacy, inspires me to return to this theme again and again.

I am deeply moved by having had the chance to discuss matters with Henrik Otto Donner, M. A. Numminen, Ralph Lundsten, Leo Nilsson, Hannu Viitasalo, Philip Donner, Pekka Sirén, Pekka Hoikkala, Risto Rautee, Seppo Nikkilä, Otto Romanowski, Joe Davidow, Jouko Kottila, Kari Hakala, Emu Lehtinen, Pertti Lehto, and Andrew Bentley.

The first interview I conducted was with Erkki Kurenniemi in 2004, together with my closest Kurenniemi research colleague Jari Suominen. Our epic almost five-hour session in the Vironkatu Studio is something I will always remember. I also have many lovely memories of subsequent encounters with Erkki and his widow Kati Heickell. My warmest thanks go to you, Kati, for everything. I would also like to thank Erkki's daughter Aurora Ikävalko, whom I contacted only very recently: she helped me with some details and permissions regarding the research material.

This study would have been much poorer without the support, help and private research material archive of composer Jukka Ruohomäki. I am honored to follow the path he cleared some fifteen years before I came on the scene. Our frequent meetings in Oulunkylä typically lasted hours and covered several aspects going beyond the topic of this study. Many thanks for these seemingly endless and always deeply inspiring discussions, Jukka!

Unfortunately, I was not able to talk with Osmo Lindeman or his wife Sirkka Lindeman. However, I have been fortunate enough to talk with Dr. Marjaana Lindeman, who even trusted her father's wonderful archive to the UHMRL collection. Her help with the research material was invaluable, and her kind support has been a great inspiration to me as a PhD student. My warm thanks to you, Marjaana!

I am deeply indebted to my supervisors Dr. Kai Lassfolk and Dr. Alfonso Padilla, who have patiently, year after year, supported me, always finding the time to read and comment on my ever-changing disposition and unfinished drafts. My friendship with Kai goes way beyond this dissertation, and even beyond our collaboration in the Kurenniemi research group. Amid all the arbitrary pressures our organization has repeatedly faced over the years, his painstaking efforts to fight for the existence of the University Studio has kept our projects alive. Alfonso was the one who gently forced me to embark on my PhD journey after a couple of years break following my MA. His remarkable expertise in many fields of the arts, social sciences and humanities is astonishing. It has been the uncompromising attitude of both of my supervisors that has opened my eyes to what there is to pursue in science and research.

For a few years I have been hoping that the best scholars in our field would review this thesis. Frankly, I never dreamt that my first choices would accept the job. I was therefore very excited when I heard that both Dr. Andrew Bentley and Dr. Trevor Pinch were willing and interested in reviewing my work. Dr. Bentley was an obvious choice given his deep expertise and experience in electroacoustic music, starting from the early 1970s in York and later, from the mid-1970s onwards, in the Finnish context: he even has first-hand experience of Kurenniemi's instrument.

It was some time in the mid-2000s that I first came across *Analog Days*, a book about the history and impact of an analog synthesizer written by Trevor Pinch and Frank Trocco. A few years later when I started to read sociology-based technology studies, I realized that the STS field was to all intents and purposes founded by the very man who had written the inspiring *Analog Days*. Having two pre-examiners with such expertise in all the key themes I cover in my thesis has been a great honor as well as an invaluable help in terms of improving the quality. My warmest thanks are due to both of them for their very sharp and insightful comments on my work.

I could not have been happier when I heard that Dr. Heta Pyrhönen had accepted the invitation to act as the Custos at the public defense of this dissertation. I was privileged to work for two years as one of the first salaried PhD Students in the Doctoral Programme in Philosophy, Arts and Society, which was set up and run by Dr. Pyrhönen. I will never forget the day in mid-December 2013 when, to my surprise, she rang to tell me that I had been selected for the position. I was also very happy to hear that Dr. Martti Vainio had agreed to act as the representative appointed by the Faculty of Arts: he was among the first persons I came to know when I started to work in the Department of Phonetics Library in Vironkatu in the 1990s. I have very warm memories of our discussions of music and sound (technology) in those distant days.

I could not believe my luck when Dr. Juha Torvinen and Dr. Olli Sotamaa came to my help during the last weeks before I submitted this study for pre-examination. Amid his significant workload, Juha was forced suddenly to take over, he managed to steer this project in the right direction and towards its completion. Given his extensive experience, Olli managed to convince me that the manuscript was ready to be submitted. Apart from being distinguished scholars in their own fields, and very inspiring as supervisors and teachers, I am very happy to call them both dear friends.

Over the years, and now on these final steps of this project, the support and uncompromising comments offered by my closest childhood friend Jaakko Tuohiniemi have been extremely valuable. Jaakko has played a significant role in so many phases of my life, which in itself could fill the pages of a book. It may well be that this study would not exist if he had not told me about the open position in the Department of Phonetics library in the mid-1990s, for example. As a token of his meticulous attention to detail I advise the reader to take a look at the *CiP data* on the colophon of this book. Thank you, Jaakko, for your friendship and for your help at every turn.

Inspiring support on the last steps of this project came from a somewhat unexpected direction. The shape that my text has taken during the last couple of months is due to my wonderful language reviser Joan Nordlund. Her excellent revisions and comments really helped me to see this thesis from a different angle and to achieve the semantic clarity that was lacking not only in the text but also in my thinking. My sincere thanks to Joan – your last-minute support and help are of vast significance.

I have been very lucky to conduct this project in a very inspiring environment. My closest context research-wise has been our Kurenniemi research group, together with Kai, Jari Suominen and Maiju Jouppi. I cannot thank you enough for our collaboration! You have repeatedly sent me back in the right direction from my many sidetracks.

Amid the closest Kurenniemi researcher group I have been fortunate to collaborate with several distinguished scholars and experts in the field, to whom I am extremely grateful. Our interest in the usability of Kurenniemi's instruments emerged very early on. In order to strengthen our understanding of user experience and interface issues I contacted my close friend Titti Kallio and asked for help. Our collaboration led to our first international conference paper on Kurenniemi's instruments, which has retained its significance over many years. Our mutual research interest with Marko Home led us to conduct memorable and timely interviews. Marko's expertise as an art historian and a researcher, as well as his extensive knowledge of the avant-garde and experimental art scenes of the 1960s and 1970s have been very inspiring and helpful.

Electroacoustic, electronic and experimental music in Finland – Kurenniemi's instruments included – have attracted the interest of many people over the years. I have been fortunate enough to network and discuss these issues with several experts in the field, to whom I owe many warm thanks! Tanja Tiekso, Kalev Tiits, Erkki Rautio, Jukka Mikkola, Jukka Lindfors, Atte Häkkinen, Petri Kuljuntausta, and Pertti Grönholm have made significant contributions. Their works and our communication have inspired and facilitated my own work. Our efforts with Joasia Krysa and Jussi Parikka led to the MIT Press anthology – my sincere thanks to both for our very inspiring collaboration.

This dissertation would not exist without several excellent archives preserving valuable historical material. The inspiring spirit I felt in every archive in which I worked during this project was amazing. On many occasions, my contact with these archives was not restricted to the material, and also included enthusiastic discussions about the importance of its preservation. Your work with fragile and highly valuable cultural historical heritage is invaluable – many warm thanks for all your help to Maritta Mellais (The Central Art Archives of the Finnish National Gallery), Eva Andberg (the Finnish Broadcasting Company's archive), Sinikka Jokinen and Johanna Oksanen (Lehtikuva archive), Mietta Lennes (The Language Bank of Finland), Pälvi Laine (Theater Museum Archive), Rauno Rankinen (Oulu Symphony Orchestra archive), Jari Eerola (the archive of the Student Union of the University of Helsinki), Kari Laitinen (Music Finland's archive), Sofia Vainio (The Amos Anderson Art Museum archive), and Petri Tuovinen (The National Library of Finland).

Endless discussions and collaboration with Esa Lilja and Lasse Lehtonen, my dearest colleagues in Helsinki-based musicology and close friends even beyond the research world, have been a great inspiration. Your escape to Norway and Japan, respectively, has depleted our local culture here in Helsinki. And although we met relatively recently, Aaro Sahari, a distinguished historian of various fields in technology, from ships to music, could be held responsible for an amazingly large part of my academic networks – in Helsinki, nationally and even internationally. Our lunch meetings usually stretch out for a couple of hours of enthusiastic debate about how to study music, history and technology. Thanks, Esa, Lasse and Aaro, for the countless discussions!

The atmosphere in the Department of Musicology, first in Vironkatu and then in Topelia, has always been very special and inspiring. Thank you for creating that warm and welcome environment for students and researchers, and for all the discussion and comments on my works over the years: Irma Rinne, Eero Tarasti, Pirkko Moisala, Harri Suilamo, Erja Hannula, Pauli Forsell, Pauli Laine, Riitta Rainio, Nina Öhman, Elina Seye, Timo Laiho, Riikka Hiltunen, Hanna Isolammi, Márta Schmidt, and all my fellow students – as well as Dario Martinelli and Lina Navickaitė-Martinelli, who are sorely missed after their move to Lithuania. I could not be happier to hear that Susanna Välimäki is making a comeback in the University of Helsinki after years of absence when she takes up the post of Professor of Art Studies in December 2020.

I would also like to thank all those in local and international contexts who have had an influence on my work by editing my texts or commenting on my papers in various seminars and conferences. Several editors of *Musiikki* have had a significant impact not only on my texts but also on my trains of thought. Many warm thanks to Juha Ojala, Ari Poutiainen, Milla Tiainen, Tuire Ranta-Meyer, Laura Wahlfors, and Henri Terho.

Our local seminars and networks are invaluable as venues in which scholars and students feel welcome to present even sketchy papers without fear of being rejected. Thank you for creating a very warm atmosphere, commenting on my unfinished notes and helping me in various ways: Kaarina Kilpiö, Vesa Kurkela, Olli Heikkinen, Saijaleena Rantanen, Antti-Ville Kärjä, Mieko Kanno, John Richardson, Meri Kytö, Heikki Uimonen, Robert Vierling, Anu Lahtinen, and many others whom I may have neglected to mention.

In the international context I have been privileged to discuss with and receive comments from the top scholars in our field – thank you Simon Emmerson, Leigh Landy, James Andean, James Mooney, Mark Katz, Jonathan Dunsby, Hans Joackim Braun, and Susan Schmidt-Horning, among many others, and especially participants in conferences related to electronic music studies such as EMS and AHEM.

The University of Helsinki Library has a very special role in my life. I simply cannot imagine a better place to work. My last five years in Data Support has had a significant influence even on this study. However, it is not the organization but the people who make the difference. My warmest thanks for your compassion and patience, and for our inspiring discussions on RDM and other research-related issues to; Pälvi Kaiponen, Johanna Lahikainen, Marja Moisio, Mari Elisa Kuusniemi, Tuija Korhonen, Liisa Siipilehto, Monica Allardt, Maija Paavolainen, Katri Larmo, Markku Roinila, Juuso Ala-Kyyny, Tanja Lindholm, Kimmo Koskinen, Mika Holopainen, Jussi Männistö, Kimmo Tuominen, as well as Leena Koivula and Tuula Ruhanen. Many thanks to my Minerva colleagues as well as my ex-HULib colleagues Susanna

Nykyri, Jari Friman and Siiri Fuchs. Very special thanks to Soile Manninen for your help in resolving obscure legal issues related to the re-use of research material, and to Pekka Manelius for taking care of all the e-publishing connected with this study.

From time to time my work with the Kurenniemi project has led me beyond the academic context to the world of arts – an inspiring journey that has taught me a lot about my research subject. I have been privileged to work and perform with distinguished artists and musicians, including Mikko Turunen, Tanja Tiekso, Tommi Keränen, Carl Michael von Hausswolff, Mika Vainio and Ilpo Väisänen from Pan sonic; Topi Tateishi, Ilona Jäntti, Johan Svensson, Halldór Úlfarsson, Aku Raski, Tarek Atoui and DIMIs Reconnected; and the DIMITrio as well as Sami Klemola and the Defunensemble. Thank you so much for these wonderful adventures in experimental music. I am deeply grateful to Mika Taanila for the various events and projects in which he has invited me to collaborate. My sincere thanks, Mika!

On many occasions the venue for these performances and concerts were provided by the Museum of Contemporary Art Kiasma and Kiasma Theater, where I always feel as if I am coming home. Many warm thanks to Sanni Pajula, Mari Kujala, Jonna Strandberg, Joonas Pehrsson, Kati Kivinen, Esa Niiniranta and Leevi Haapala, as well as Perttu Rastas for his enormous contribution to preserving Kurenniemi's legacy and his help with several issues with the research material.

The support and compassion from friends and relatives over the years has been heart-warming. Many warm thanks to Outi and Sami Paldanius, my dear goddaughter Emilia Paldanius, Jenni Hokka, Jari and Minna Hildén, Jani Tihinen and Salla Heino, Tomi and Mirva Kokko, Henri Penttinen, Juhana Lahtinen, Marjatta Ruotsalainen, Nina Sarvana and Esko Salmela, as well as my dearest Tonde People, who annually witness and empathize with my highs and lows at our convention.

These sorts of projects take the biggest toll on those who are the closest – but let us hope that they are, at least to some extent, also rewarding. I have no words to describe my gratitude to Maija and Raimo Ojanen for their immense support at every turn throughout this project and beyond. Thanks, too, to my brother Aleksi Ojanen for dragging me out of my dungeon from time to time.

Anne – I really do not know from where you have found the strength to bear with me, and this project for ten years. It is perhaps not fair to remind you that you suggested I start it – but I am glad that you did. I realize that I should have ended it much sooner. My deepest gratitude to you for your loving support and invaluable help. Thank you for being there.

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I received funding for this project for 45 months as follows: the statutory Adult education allowance from the Employment fund from August 2010 to December 2011 and for November 2012; a two-year salaried PhD student position at the University of Helsinki, Doctoral Programme in Philosophy, Arts and Society (2014–2015); and a three-month University of Helsinki PhD finalizing grant from December 2018 to February 2019.

University of Helsinki travel grants have enabled me to present my work to the international research community in the IMS12, EMS12, EMS14, ARP14, AHEM16, ICOHTEC18, SISC20 and EMS21 conferences. I also received research material funding from the The Doctoral Programme in Philosophy, Arts and Society, and from the Student Union of the University of Helsinki. My sincere thanks for this financial support, without which I would not have been able to realize my project.

Oulunkylässä, marraskuussa 2020

Seelalle ja Paavolle – ja niille aivan käsittämättömille ihmettelyn ja oivaltamisen prosesseille, joihin vain pienen lapsen mieli kykenee. Olen oppinut teiltä uskomattoman paljon.

Lehtosen Masalle – ihan vain piruuttani.

1 INTRODUCTION

1.1 The objective of the study and the research task

Erkki Kurenniemi (1941–2017), one of the pioneers of electroacoustic[1] music in Finland, started designing electronic musical instruments and studio devices in the early 1960s. He built and maintained the University of Helsinki Electronic Music Studio – the first permanent electronic music studio facility in Finland. In addition to designing instruments, he produced both standalone tape music works and electronic music and sound design for various purposes including films and documentaries, radio and theater plays, and exhibitions. In 1970 Kurenniemi founded Digelius Electronics Finland, together with Jouko Kottila and Peter Frisk, to further develop his instrument design. This rapidly growing enterprise focused on large-scale industrial technology and the design of musical instruments assumed a minor role. After a short and eventful period, Kurenniemi declared Digelius Electronics Finland bankrupt in 1976. This also marked the end of his intensive instrument-design projects, but not of his involvement in the Finnish art scene or in industrial technology design.

At the time when technology dedicated to electronic music production was practically nonexistent and the building of studio facilities required specialized resources, Kurenniemi's designs enabled the work of several composers and artists in Finland and Sweden to be realized – also in various experimental art genres beyond the field of music. Kurenniemi was designing his instruments at the same time as Robert Moog, Donald Buchla, and Peter Zinovieff, pioneers in the design of the synthesizer, and experimental instrument builders Hugh Le Caine and Hugh Davies were active. This was when what is recognized nowadays as a plethora of sub-genres of electroacoustic music was in its infancy, and when such music was heard for the first time in Finland.

The forthcoming instrument of the future was widely anticipated during the 1960s. The decade was one of intensive interplay between technological idealism and realism, in other words between utopian visions and their simple and sometimes modest implementation on a concrete, grassroots le-

[1] At times, I use the terms electronic and electroacoustic music interchangeably. It is worth noting that the term electroacoustic music was used in Finland only from the 1970s onwards. Moreover, the history and aesthetics of electronic music is intertwined with intangible concepts such as *experimental*, *avant-garde* and *underground culture*. For a more detailed discussion about the definitions of these terms and how I use these concepts within this work, see Chapter 2.

vel. Great expectations were laid upon technological development. The new and envisioned technology provided new opportunities, which motivated designers and artists to reach for novel solutions. Designers of electronic instruments tried – at least to some extent – to break free from traditional user interfaces and musical expression, even though the designs were also tied to the tradition, especially when assessed and received. From the perspective of historical research the period gives significant insights into the ruptures in technological developments in music, and reveals details that would otherwise be hidden. My main research focus in this study is on the use of Kurenniemi's instruments, which offers one view of this rupture. *User stories of Erkki Kurenniemi's electronic musical instruments* also complements previous descriptions of electroacoustic music in Finland, and to some extent in Sweden, during the 1960s and 1970s. First, I will contextualize the title of the study.

1.1.1 Contextualizing the study

Outlining *user stories* is a systematic method in the assessment of modern agile software development. The stories are based on informal but structured natural language phrases. The term is also loosely associated with the research on technological artifact design, which is of relevance here. Previous research projects have neglected the composers and artists who used Kurenniemi's instruments. I focus on the users, hence the phrase – user stories – aptly emphasizes my point of view. Even though such stories would constitute an effective formal method as such, I only borrow the phrase for the title of my study and do not systematically employ them as a methodological tool.

Erkki Kurenniemi has an indisputable key role in this study. I retain his name in the title, even though his work serves as a point of departure for wider investigation. Research setups focusing on one person have been criticized for overshadowing other actors in the field, and such a critique is valid here. Previous research and documentary projects have presented different actors in the field of electronic music as separate subjects and have thus – sometimes accidentally – concentrated on telling the tales of "great men". On the other hand, the critique is not fully justified in this case. Kurenniemi's contemporaries repeatedly report, one after the other, how exceptional he was, and put him above or in front of others. Moreover, generation upon generation find, study and appreciate Kurenniemi's work – even though interest has repeatedly faded and has been re-activated. The adoption of Kurenniemi as an idol by the gradually emerging Do-It-Yourself (DIY) community during the past 20 years, first in Finland and later internationally, is an excellent example of phased development. Moreover, Kurenniemi is a micro-historical *typical exception* par excellence: on the local level he was an exceptional figure and from the global perspective he was a typical example of the (techno) visionary artist of the 1960s and 1970s.

Kurenniemi has frequently been described in the media as an unsung pioneer. He is no longer an unsung pioneer, and now we have a new group of forgotten heroes. Taking a critical approach towards previous descriptions of Kurenniemi's work, I give him the credit he deserves and acknowledge the contributions of others who were once close to him and are now shadowed by research that concentrates solely on his work. I analyze his instrument design in its social context and refuse to depict him as an isolated visionary genius. Thus, this study is not solely about Kurenniemi. His work serves as a lens through which to observe the cultural and historical state of electroacoustic music in the Nordic countries in the 1960s and 1970s.

The phrase *electronic musical instruments*, used in the title, indicates that my point of departure is technology. I acknowledge that the starting points of a study strongly direct the analysis and interpretation. My choice of Kurenniemi and technology as the points of departure will produce a different description of the development of electroacoustic music in Finland than if I had chosen to start from another angle. I am sensitive to this issue and elaborate its effects in the conclusions. Lastly, I decided to use the phrase "*music**al** instruments*" rather than "*music instruments*" to emphasize playability and the creative aspect.

The subject of my study has already been addressed by several researchers. I elaborate on and contextualize the theme more thoroughly than others have done, however. The significant new information discovered in the historical documents enriches and revises previous descriptions. Complementing these new historical findings, recent interviews conducted with the actors who were active during the time frame of this study help to shed light on hitherto shadowy details. The new information and interpretations challenge previous accounts of the history and development of electroacoustic music in Finland. Yet, at the same time I acknowledge that history writing is a construction of the present-day writer and that understanding of the past is relative.

In 2016, at the Alternative Histories of Electronic Music conference, I was asked what there was in Kurenniemi's work that would help to portray electroacoustic music from a new angle. Was there something that could be generalized? To give wider relevancy to my study, I also set a theoretical target. My attitude towards theory is close to that of Katz (2012, 8–9), whose ethnography- and history-driven studies leave ample space for the stories and focus on the "social, cultural and historical contexts" in which his research subjects lived, and events occurred: concepts and theories only lurk in the background. However, it is necessary to review existing theoretical and methodological literature in some detail to anchor this study in previous academic discussion. Therefore, I dedicate two chapters to the key concepts and theories (see Chapter 2) and my methodological toolbox (see Chapter 3).

Moreover, beyond the temporal and geographical frames that constitute the local level (see the framing of the study in Chapter 1.1.2), the works of Kurenniemi and his Nordic collaborators provide sufficient material for an overarching analysis of interaction between music and technology – which is sensitive to the historical contextualization. Within this wider scope, I describe Kurenniemi's designs and art as a technology-driven process, exemplifying an artist who works in close – and often real-time – interaction with the production technology. In extreme cases, the role of technology is strongly emphasized and may even be the main factor in the production process. In my analyses of both Kurenniemi's own and his collaborators' user stories I reveal the contrast between the world of engineering and the world of artistic activity. Summarizing the previous literature and my own study, I conclude that Kurenniemi's computer-metaphor-driven instrument design strongly directed the building, marketing, selling and use of his instruments, and that this kind of technology-driven music production diversifies the traditional concept of a work of art and its valuation.

1.1.2 The key concepts and the research questions

This study belongs to the research domain of music technology, and the scientific stance is interdisciplinary. Many of the concepts I employ could be defined and understood in several ways. I anchor them in previous literature or re-define them in the context of this study. I employ concepts from different areas that have explanatory power over the subject of this study. Heeding the warning given by Bijker & Pinch (2012, xviii), I avoid conceptual chaos and explicitly define terms in cases of conflict. Many of the terms I use here are operative background concepts, and in many cases I do not necessarily apply the whole theoretical package that comes with a single concept.

The methodological toolbox of the study emphasizes qualitative research. My key methodological concept is that of *pertinences*, initially deployed by François Delalande (1998) in the context of electroacoustic music analysis. Pertinences are features of a musical work that are considered relevant by the analyst and lead to the analysis. I see a significant resemblance between pertinences – as described by Delalande – and both the collection of qualitative observation data and archival research in history and technology studies. Despite my emphasis on the qualitative approach, I do not prioritize qualitative over quantitative methods: on the contrary, quantitative methods would be very beneficial to the analysis. I nevertheless leave quantitative approaches for forthcoming projects. Their implementation would have required a different research design from the very beginning of the project.

Here, I take my methodological cue from Pinch & Trocco (2002a) and follow the instruments to where they were used – in the hands of their users. We described this task as one of the further research suggestions in our first article on Erkki Kurenniemi's instruments, published in 2005 (written jointly with Jari Suominen, see Ojanen & Suominen 2005).

Within the main task, the three key themes of the study are *music history* (the historical and cultural context in the Nordic countries in the 1960s and 1970s), *music technology* (the design and use of electronic musical instruments), and *electroacoustic music* (aesthetics and musical analysis). These helped me to frame the more specific perspectives – both conceptual and related to the research questions. Even though different disciplines speak different languages, I see much in common with history, technology and music studies. Similar terminology serves to describe many features of both technological artifacts and musical works. For example, the treating of innovation success or failure in technology studies strongly resembles the criticism presented in the various history-from-below approaches of modern historiography, or critical attitudes to canonization in music (history) studies. All of these emphasize an analytical turn to marginal and less-closely-examined phenomena.

One effective way of achieving a thorough understanding of a subject is to approach it from various points of view and with different methods. Thus, I employ conceptual, methodological and theoretical *triangulation*, as described by Denzin (1970a, 297–313; see also Rothbauer 2008). Composer and researcher Leigh Landy made a plea for triangulation in the study context of electroacoustic music in the late 1990s. He was concerned that sound-based music was not being studied by researchers interested in note-based music, in other words that traditional musicological tools were not being used to study electroacoustic music. Landy also suggested that even the inclusion of other research branches might be potentially beneficial. (Landy 1999, 68) The plea for triangulation reflects the concept of the *seamless web*, which is used especially in Science and Technology Studies (STS) to emphasize the fact that a priori categorization directs the interpretation of phenomena. Thus, technical, social, political, and economic categories should be considered together as a "fabric which has no seams". (Hughes 1986, 284–287)

From the *historical perspective*, I ask what happened. Even though a lot of work[2] has been done to describe the electroacoustic music scene in Finland in the 1960s and 1970s, there is still a need for basic research on the local level, in other words the scene in Finland. Previous research has focused on Kurenniemi's instruments[3] as physical artifacts, and on his design process in general. It is known what instruments he built, where they are and how they work but little has been written about how they were used. Events, works of art, actors, and instruments that have been identified thus far have been considered on a general or popularized level, and only rarely more thoroughly than as a brief mention in biographies of composers and artists, or in retrospective reviews of the electroacoustic music of the 1960s and 1970s. There are still works of art and their authors to be discovered, there

[2] See the literature review in Chapter 1.3.
[3] Most of the instruments are owned by and located in the University of Helsinki Music Research Laboratory and Electronic Music Studio (UHMRL), where they can be played and studied. I present Kurenniemi's instruments in Chapter 6. The presentation is concise, and it is based on my previous research projects in collaboration with Jari Suominen and Kai Lassfolk. For detailed and updated information about the instruments, the reader is advised to visit Kurenniemi's instruments online website at http://ekis.helsinki.fi.

are still loopholes in timelines and events to be described. My aim in this study is to fill some of the gaps in the historical timeline and to describe the previously unknown works and composers I discover.

When I first considered this subject, I assumed that it would be possible to employ a ready-made historiographical method. During the past 15 years, for example, many Finnish writers on music history have used microhistory as a theoretical and methodological toolbox in their projects. A closer reading of historiographical texts, however, revealed that there was no overarching method that I could adopt. On the contrary, the historian constructs new interpretations in a close interactive process in which the researcher, the subject, and the previous theoretical background intertwine in a unique way.

I subscribe to the view of history writing based on what we *know* and *do not know* about the past, and draw conclusions following a critical assessment of that knowledge – rather than arguing for or against how things really were in the past. The key historiographical concept I refer to is that of *unresolving tension* introduced by historian Allan Megill (2007, 1–3), which emphasizes the relativeness of current understanding of the past. A historian's task is to bring to light the problems and loopholes rather than writing them out of the narrative. Megill's guidelines are detectable in the work of several other history writers – especially microhistorians Carlo Ginzburg and Giovanni Levi.

Amidst the unresolving tension I employ concepts and methodological tools from the field of history writing such as the *typical exception* and the *scale of observation* outlined by Ginzburg (1993; 2012) and Levi (1991; 2012). Even though microhistory has been widely used "as such", Ginzburg's and Levi's texts reveal that it is not a unifying principle per se, but an umbrella term loosely pulling several research streams together. Indeed, it is sometimes hard to distinguish it from other trends in new history writing (Peltonen 2002). It would be tempting to label this project a microhistorical study but, given that I do not systematically or exclusively use microhistorical tools, it would be misleading. From the historical perspective it is about music and cultural history, and the history of technology. Thus, I refer to a broader collection of historiographical approaches rather than one theoretical frame. I review these concepts more closely in Chapter 2.1.

From the *technological perspective*, I ask if the composers and artists *engaged* with Kurenniemi's designs and if they contributed to his design process. I also ask whether the users 1) accepted his instruments as intended, 2) accepted them with modifications or 3) rejected them altogether. I also assess the development of his design process and employ tools from recent digital musical instrument (DMI) research. My interest also extends to the *sociotechnical change* that Kurenniemi's case exemplifies. One of the reasons why most of his instruments remained in a prototypical state, for instance, was because few people used them. User experiences did not circulate back into the design process, as they did in the development of the electric guitar and the analog synthesizer.

Even though Kurenniemi realized most of his instruments single-handedly, his design process was directed by the *relevant social groups* in the avant-garde art scenes in Finland and Sweden. At the time, the process of designing electronic musical instruments – to be recognized later mainly as synthesizers – was affected by *interpretative flexibility*. In other words, electronic musical instruments did not have one stable meaning or purpose, as the different social groups close to Kurenniemi had their own hopes and needs concerning the new tools. It was only later in the 1970s that the internal structure and user interface of these new musical tools standardized and stabilized, and the synthesizer became recognized as a keyboard instrument.

Kurenniemi's instrument design was driven by computer-technology-related concepts such as automation and programmability, which also strongly directed the use of the instruments. There were several, even competing, definitions of the computer in the 1960s, but to argue for or against any one of them is irrelevant here. To elaborate on this, I introduce the phrase *computer-metaphor-driven processes*. The *computer metaphor* refers to all the hopes, wishes, expectations, anticipations, and sometimes even fears that Kurenniemi and his contemporaries entertained about the new technology, as opposed to giving a static unequivocal definition.

The concepts of *success* and *failure* are often discussed in connection with Kurenniemi's work. He was a successful tinkerer, but he failed as an instrument marketer. His instruments were not identified as musical instruments such as home organs, pianos or electric guitars, nor were they identified as music-specific computers, which rendered them in between worlds. To some extent this led to the failed marketing and branding and – even further – to the nonexistent distribution.

Kurenniemi's work exemplifies the audio hardware hackerism practices described in the local Do-It-Yourself context. Reflected against modern DIY hack-labs, his work had many similarities with current practices – but also differences. As instrument designer and composer Nicolas Collins (2006, 7) points out, many current hack-lab designs are short-lived – not only by accident, but also in line with their primary purpose. As well as designing one-off case-specific instruments, Kurenniemi also aimed at the mass production of commercial instruments. Case-specific design was a minor concern in his design process, even though most of his instruments were one-off. The company he founded to produce them, Digelius Electronics Finland (1970–1976), could not turn the instrument-design process into a commercial success, or even start mass production.

Here, the Kurenniemi case exemplifies how the point of departure of an analysis significantly directs interpretations of the phenomenon. There is a difference between seeing the instrument-design process analyzed here as commercially driven or as based on DIY practices. To clarify interpretational contradictions such as these, and as an outcome of my study, I outline a framework and categorization that could be useful to scholars doing historically sensitive research on music technology – especially when making assessments such as those related to the questions of success and failure. Here, I return to the STS approach and employ the *symmetry principle*, according to which the failure and success of an innovation should be explained using the same terminology. The *working* or *non-working* of an instrument is not among its intrinsic features, but is an outcome of the implementation process: it is something that needs to be explained, not something that explains the success or failure of the design (see Chapter 2.2).

Closely related to concepts from Science and Technology Studies (STS) is the concept *boundary shifter*, devised by Pinch & Trocco (2002a; see also Pinch 2009, 190), which they use to describe Robert Moog's ability to move between the worlds of art and engineering and to bring about a transformation in both worlds. This is where Kurenniemi differs from the users of his instruments. Not unlike Moog, but in contrast to his local contemporaries, he was able to cross the boundaries between art, science, and technology. I review the other STS concepts I employ in this study in more detail in Chapter 2.2.

From the perspective of *music analysis*, I ask what the musical works completed with Kurenniemi's instruments reveal about the technology used in their realization. Here, I avoid falling into technological reductionism and consider the use of his instruments in complex interaction among users, technological artifacts, and the tradition of music aesthetics that the works realized with his instruments reflected. Aside from the historical and technological aspects, Kurenniemi's instrument designs, music and media art exemplify how sociotechnical change is reflected in aesthetics. The various musical expressions and styles he and his colleagues combined in their work even brought art and popular music closer together. For a period during the early days electronic media was beyond the immediate value judgement of high art and popular cultures. The synthesizer of the late 1960s that was intended to compete with traditional instruments was commonly rejected by classical music enthusiasts, for example. Nevertheless, even though the reception of electronic music composer Wendy Carlos's synthesizer arrangements of Johann Sebastian Bach's works on the album *Switched-on Bach* was hostile, the album sold millions of copies.

It is also true that various traditional instruments have been played to reflect any musical style. It would seem, therefore, that value judgements are not associated with the instrument per se, but are dependent on the way it used, and on the context in which it is played. Both classically trained composers and artists working in the production of popular music have been equally attracted to electronic sound production and processing. These composers and artists differed in the way they used Kurenniemi's instruments and in the role they were willing to give the technology in their workflows.

To focus my analytical perspective and elaborate on the impact of the new technological artifacts on the definition of a *musical work*, I adopt the tripartition model developed by Jean Molino and Jean-Jacques Nattiez. Even though I do not use Nattiez's semiological tools, I find the distinction of the *poietic* and *esthesic processes*, and of *the musical work* per se a useful point of departure from which to map the details of the analysis. Concentration on the poietic process of the composer, or on the reception or receiving process of the audience/listener, or on the work on the level of its material reality, leads to different interpretations.

As Emmerson & Landy (2016, 22) acknowledge, a musical work in a technology-oriented genre loses at least some of its pivotal meaning if analyzed only in terms of its reception, in other words if the *poietic leakage* is not considered. To emphasize the concept of *technology-driven music production* I develop the tripartition further, describing the *poietic ecosystems* of composers using Kurenniemi's instruments. The poietic ecosystem comprises not only the composer's poietic process but also the technological artifacts and his or her complex relationship with these tools.

Here, distinguishing between a *musical work* and *music* plays a crucial role. Kurenniemi is an example of an artist whose output challenged the traditional meaning of music considered a *work* of art. In line with philosopher Lydia Goehr's (2007) division into music and musical works, I argue that Kurenniemi did not compose musical works, but rather produced music. In this respect, his visions of the future music machine are in line with the development of so-called background music, or muzak, and music used as soundscapes in on-demand situations (see Hamilton 2007, 54).

1.1.3 The framing of the study

This study is rooted in the period when Kurenniemi designed his instruments and when they were actively used in Finland. My observations date from the foundation of the University of Helsinki Electronic Music Studio in 1961. The studio did not have an official name at first, and was variously known as the University Studio, the Sound Technical Laboratory, Kurenniemi's studio, and the Electronic Music Studio at the University of Helsinki, among other things. Today the studio is called The University of Helsinki Music Research Laboratory (UHMRL), but in this study I refer to the *University Studio* (see also Chapter 5.1).

There is no exact date when Kurenniemi's instruments fell out of use – it happened gradually. Usage in Finland declined over about 20 years, from the turn of the 1980s to the early 2000s. In Sweden, however, composer Ralph Lundsten (b. 1936), who purchased several of the instruments, used them continuously in his Andromeda Studio. He dismantled the studio in 2014 and donated the instruments and the equipment – apart from the video-camera-controlled synthesizer DIMI-O (1971) – to the Musikmuseet[4] in Stockholm. The Finnish State Art Commission purchased the DIMI-O from Lundsten in 2014 and placed it in the University Studio in Helsinki.

[4] The current name of the organization is Scenknostmuseet, teater, musik, dans, kultur (the Swedish Museum of Performing Arts); see https://scenkonstmuseet.se/.

I end my observation in the year 1978, two years after Digelius Electronics Finland went bankrupt and Kurenniemi moved from Helsinki to work on industrial robotics at the Rosenlew Company in Pori. Specifically, on August 21, 1978, Kurenniemi once more returned to the topic in the electronic music seminar organized by UNESCO, at which he presented a retrospective of his instruments. The seminar was recorded, and the 90-minute sound recording was archived in the UHMRL sound archive.

Even though the resurgence of Kurenniemi's instruments from 2002 provides interesting research material for comparative analyses of the sociotechnical change, comparison of the past and the present is not in the scope of this study and is left for forthcoming projects. I acknowledge that my experience both as a performer on Kurenniemi's instruments and as a member of research projects in collaboration with Jari Suominen and Kai Lassfolk during the 2000s has influenced my interpretation of their historical context. During our performances and research projects we discovered new ways of using the instruments and new sonic expressions, which do not feature in the contemporary historical source material. Here, I am sensitive to hindsight and consider that I know more than Kurenniemi's contemporaries knew, or could have known, in the 1960s and 1970s about how the story continued.

Geographically I concentrate on events in Helsinki and Stockholm. Apart from a few exceptions – such as the sounds from Kurenniemi's first music machine (1964) that were broadcast on Radio Andorra in 1965, and the Andromatic synthesizer-sequencer (1968) that toured in the New York exhibition in 1969 – most appearances of Kurenniemi's instruments were in Finland and Sweden. I prefer the phrase "electroacoustic music in Finland" rather than "the Finnish electroacoustic music" and avoid making statements on exactly what Finnish electroacoustic music is. Musical genres and trends rarely follow nationalities or state borders. Electroacoustic music in Finland, at least in the early phase, was strongly influenced by happenings and performances by Ken Dewey (1934–1972), Terry Riley (b. 1935), and John Cage (1912–1992), and ideas presented in Internationalen Ferienkursen für Neue Musik in Darmstadt, for example. Moreover, Kurenniemi actively collaborated with Swedish artists such as Jan Bark (1934–2012), Folke Rabe (1935–2017), Ralph Lundsten, and Leo Nilsson (b. 1939). As I note in this study, the original ideas directing Kurenniemi's designs can be traced to contemporary publications and seminars, and his connections. The initial design ideas for the University Studio, for example, strongly resemble those for Elektronmusikstudion (EMS) in Stockholm, which were coordinated by Knut Wiggen (1927–2016) and Karl-Birger Blomdahl (1916–1968). Kurenniemi met Wiggen as early as in 1963.

Questions of nationalism should not be dismissed, however, and closer consideration of them should be given in further studies. When he was assessing thirty-year-old events in 2002, Kurenniemi considered the challenging geographical location one of the possible reasons for the poor commercial success of his instruments. In his view, their origins in Finland "almost behind the iron curtain" may have been one reason why potential customers failed to buy the DIMI synths (see Taanila 2002). Furthermore, given that Kurenniemi and his collaborators chose to include Finland in the name of their company Digelius Electronics Finland, and that the word Digelius is a combination of the word *digital* and the name of the Finnish National Composer Jean *Sibelius*,[5] more detailed study on the national aspects of Kurenniemi, Digelius and *Finnish* electronic musical instrument design might prove fruitful.

1.2 Research material and data

The primary objects of this study are Kurenniemi's electronic musical instruments and works of art, and events associated with his designs.[6] The works and events associated with the University of Helsinki Electronic Music Studio are also of interest, because I consider the studio to have been Kurenniemi's first instrument-design project. In the following I first introduce the material and data collected for this study, and then the material and data produced during the course of it. Lastly, I review the ethical issues concerning the archiving and opening of the material and data reused and produced within the study.

1.2.1 Research material and data collected for the study

According to the modern historiographical paradigm, historians accept diverse types of fragmented series of documents as source material.[7] Among published contemporary historical accounts, this study is largely based on non-catalogued, unorganized, fragmented documents and physical artifacts of various kinds. A certain unfinishedness, which is a distinctive feature of the source material, challenges the research and leaves a good deal of room for interpretation. For example, markings on the tape reels are sparse, the musical instruments lack a user manual and the technical specifications are defective, and most of the archive material is undocumented (on Kurenniemi's unfinishedness see Taanila 2002). One laborious sidetrack in the study was to ensure the preservation of this unique material by documenting and archiving it (see Chapter 1.2.3).

A typical feature of historical, qualitative and material-driven research is that new material appears during the project and even afterwards. I ack-

[5] Kottila (2014) in an interview with Ojanen and Suominen.

[6] The primary objects are presented in separately published tables, see *Analyses of the works of art and events related to Erkki Kurenniemi's Electronic Musical Instruments (EKIS)*, see: https://doi.org/10.5281/zenodo.2092577 and *The user interface and functionality charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)*, see: https://doi.org/10.5281/zenodo.3596466

[7] For a more detailed discussion of history writing, see Chapter 2.1.

nowledge that discovering and recognizing as many events and works of art as possible is an important part of history writing and basic research, but I do not intend to describe and analyze every work ever made with Kurenniemi's instruments. Given my analytical standpoint, the material collection is saturated. Credible conclusions can be drawn from what I present here. However, I anticipate and welcome future discoveries, which will eventually enhance my interpretation. To keep this study dynamic even after I have published it, I will make the documentation of the material and the data collection openly available in the Zenodo online data archive, where I can update and revise it (see Chapter 1.2.3).

The key primary material comprises the works realized with Kurenniemi's instruments. I categorize the composers and artists as *users with first-hand experience* with the instruments, and occasional users who used one instrument very briefly, or were in in-direct contact with one (see Chapter 7). Within this study, I only concentrate on those who were in closer contact with the instruments. I therefore leave the examination of several users and their works for a future project, but I acknowledge these gaps in the current material (see Pinch & Trocco 2002a, 11).

First, Kurenniemi's instruments had more users than I can present here. There are still potential research participants I was not able to interview for this study. I could not approach everyone, some of those I did approach did not answer my call, and some of the interviewees could not recall the past. Very sadly, a few of them passed away during the project and our collaboration came to a premature halt. Second, those who tried out Kurenniemi's instruments but for some reason chose not to use them comprise another group of silent voices. Here, I can only scratch the surface of research on non-users of Kurenniemi's electronic musical instruments, which would be a very interesting line to follow to complete the picture. Third, the skewed gender balance in the research material reveals another significant group of silent voices. The almost total lack of women in the sources requires further elaboration, which is beyond the scope of this study.

Alongside Kurenniemi's instruments, their documentation, and the sound recordings and works of art associated with them, my primary source material includes rich collections of archival material. The key archives maintained by responsible organizations I employ within this study are the University of Helsinki Music Research Laboratory and Electronic Music Studio (UHMRL), the Erkki Kurenniemi archive in the Finnish National Gallery (FNG/EKA), The Finnish Broadcasting Company's (Yle) archive, Lehtikuva's archive,[8] as well as the archives of the Amos Anderson Art Museum, Ylioppilasteatteri (Engl. Helsinki Student Theater),[9] The University of Helsinki Student Union,

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[8] Finland's leading picture agency, owned by the country's largest news companies, see http://kuvakauppa.lehtikuva.fi/edoris?tem=www_e.

[9] See https://ylioppilasteatteri.fi/in-english/

The Finnish Museum of Theater, the National Archive, and the National Library of Finland.

The UHMRL archive consists of handwritten documentation about most of Kurenniemi's instruments, as well as the sound-recording archive with approximately 350 reel-to-reel tapes. The tapes related to his instruments, which I have digitized, restored and analyzed to some extent during this study, comprise approximately 20–30 percent of the archive (see also Chapter 1.2.2 below). In addition to their role as primary source material for the analysis of the musical works, the audio recordings also have documentary historical value. Aside from the sound on the recordings, the tape reels and their containers also provide valuable information.

Other highly useful material for cross-referencing in the University Studio archive collection includes Kurenniemi's daily planners (1968–1975), the inventory catalog of studio equipment (1958–1974), purchase documents for components and equipment, funding and allowance applications, annual reports, and a handwritten sound archive catalog (initiated by Kurenniemi in 1972). These documents contain information about the dates and details related to the instruments, works of art, and events. However, they are fragmented, and they should be approached with a critical eye. The annual reports of the University of Helsinki, for example, are published under the name of the current Rector at the time of publication. The real author is typically unknown, and people not necessarily involved in the activities collected the information from the department in question weeks or months afterwards. Details cannot be verified in many cases, and the exact time of writing is not necessarily known. Despite the challenges, however, the documents reveal helpful information and point out more convincing sources.

In addition to his instruments and music, Kurenniemi's body of work includes a vast amount of archival material consisting of experimental and avant-garde films, photography, paintings, media art, letters and correspondence, brochures and promotional texts for concerts and events, Kurenniemi's *Erikoistietojen kortisto* (Engl. catalog of special information), as well as writings on music, technology, media culture and future developments from various points of view. His exceptionally rich private archive is deposited in the Finnish National Gallery, where it is at the disposal of researchers. Given the variety of themes in the collection, research questions should address several different disciplines. The collection could equally attract ethnographers, art historians, sociologists, and technology researchers to name a few. Fortunately, interdisciplinary approaches have already briefly coincided in two book releases (see Mellais 2013; Krysa & Parikka 2015).

Kurenniemi constantly archived his life with non-stop note-making, photographing and recording. This activity produced an extensive collection of diaries in various formats – such as handwritten notebooks and hours of audio and video recordings. One unique source that is of relevance here is his collection of taped audio diaries (1970–1975), which consists of over 100 hours of his talk – usually when driving alone in a car. For example, when driving from Helsinki to Tampere on Sunday October 8, 1972, Kurenniemi describes his whereabouts and surroundings at a given moment, and he reads the register plates of other cars aloud. Most interestingly, he reminisces on what he did recently, where he is coming from, where he is going to, and why. This extraordinary collection of living historical source material has vast research potential.

Contemporary photographs taken by Kurenniemi and others are relevant evidence but only if the dates, contents and other details are verified, such as if the people and the objects in them are recognized. Despite their powerful role as sources in history writing, for several reasons they should be approached as critically as other sources. According to Gaskell (2001, 210), "photographs are subject to many forms of manipulation" and "different captions for the same photograph often produce radically different or even contradictory meanings." This similarly applies to videos and audio recordings: even if the details are easier to verify, they can be precisely analyzed only if their content is recognized. Both Kurenniemi's photographs in the FNG archive and the Lehtikuva archive were major resources for this study.

The archive material both in official archives and in private collections also includes contemporary interviews, which are significant especially concerning informants who died decades ago. A couple of interviews with composer Osmo Lindeman (1929–1987) from the 1970s that survive in his private collection are invaluable, for example. Valuable documents exist outside of the official archives and responsible organizations. The unpublished sets of material to be found in the private collections of research participants and other researchers are unique and fragile. Research participants are typically eager to present their collections during an interview session, and in many cases the informants are willing to share digital copies of their original material with the research project. Some even entrusted original documents to us – most notably Lindeman's collection including his tape archive, other sound recordings, books, letters, sheet music, scores, and a scrapbook.

Published contemporary documents such as magazine articles and books, biographies (typically retrospective), sound records with their covers and liner notes are all important and could be considered research material, possibly also serving as research literature (see also Chapter 1.3 on previous research on the topic and the research literature). Kurenniemi's own writings[10] and contemporary publications are significant source material, for example. Autobiographical publications such as Ralph Lundsten's books *En själens vagabond*[11] (Engl. The Vagabond of the Soul) and *Cosmic Composer*,[12] Mauri Antero Numminen's books *Helsinkiin: Opiskelija Juho Niityn Sivistyshankkeet 1960–1964*[13] (Engl. To Helsinki: Student Juho Niitty's Educational

[10] Kurenniemi (1999).
[11] Lundsten (2006).
[12] Lundsten (2014).
[13] Numminen (1999).

Projects) and *Kaukana väijyy ystäviä*[14] (Engl. Far Lurking Friends), well as Eino Ruutsalo's *Maalarin rytmiä etsimässä*[15] (Engl. In search of the painter's rhythm) contain rich pictorial material and memories, and constitute another important category of secondary source material. As sources for history writing they resemble interviews and oral-history material, and should be approached critically (see also Chapter 3.1 for methodological considerations).

Digital newspaper archives, which are accessible for a fee or for free,[16] proved valuable in complementing the material collection. Within only a few hours of browsing, I gathered 200–300 contemporary newspaper articles, news items and announcements related to this study from key newspapers such as *Helsingin Sanomat* and *Dagens Nyheter*, a task that would have taken weeks to accomplish a couple of years ago.

1.2.2 The research material and data produced within this study

The largest set of material produced within the study consists of digital copies of the original documents. The main source material of the musical works comprises audio recordings – either on original unreleased master tapes or on commercially released sound records. In their management, I created high-resolution wave files and annotated them as spectrogram images using Steinberg Wavelab audio editing and mastering software. Annotated sound files are archived as audio files (.wav and .mp3). The sonogram screen shots, which I use to visualize the audio files, are archived as pictures (.tiff and .jpg). The notes and annotations are archived as spreadsheets, tables or pictures.

An important detail to consider here is the processing of the original source material. The signal processing may result in different versions of a work and thus could even influence the music analysis. Therefore, the processing of the audio material should be considered in the interpretation.[17] This issue reflects the analysis of traditional instrumental music, which should take the interpretation of the musician, orchestra or conductor into account.

In addition to the digitized sound recordings, the collection includes digital repro-photographed tape reels and their covers, (hand)written documents (letters, notebooks, memos etc.), pictures and scrapbooks. The digitized collection will be openly available within the forthcoming FinEARS project.[18] As

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[14] Numminen (2020).

[15] Referred to via the publications of Marko Home (see e.g. Home 2013; forthcoming doctoral dissertation).

[16] See the National Library of Finland's digital newspaper archive for researchers; https://digi.kansalliskirjasto.fi/

[17] For more information about the first phase of the digitization process, see Ojanen (2015).

[18] See: http://finears.helsinki.fi; see also Chapter 1.2.3.

part of the present study I piloted the best practices and workflows for opening the material and the data.

I have produced documents based on the primary source material that could be considered research data, I and include observations of the primary objects. The observations form data sets for analysis and their collection reflects the methodological questions concerning the primary objects of this study, in other words the musical instruments, the musical works and the events (on *pertinences* see Camilleri & Smalley 1998; see also Chapter 3). These documents consist of copies of the original source material enhanced with my own notes and annotations. The second-generation source material also consists of lists and databases I have produced during this study, compiled as Microsoft Excel files with the help of the E-lomake tool provided by the University of Helsinki. To ensure their long-term preservation I have converted the spreadsheets into the .csv (comma separated) file format.

As a by-product of the digitization I have developed systematic documentation, in other words metadata, for the digitized and archived material. The production of the metadata follows a non-standardized format, based on the requirements I detected in the research project. I consider this to be research-driven-digitization and metadata production, meaning that the research questions rather than the standards direct the data collection and documentation. However, I have developed the metadata schema to be interoperable with a standardized format in order to merge the data sets with official databases such as Finna.fi or Europeana in the future.[19]

An extensive collection of secondary source material produced partially within this study consists of interviews, and oral and communicative history. I started conducting open thematic interviews in 2004, mainly with Jari Suominen, Kai Lassfolk, and Marko Home. The open interview method tends to reveal details that are otherwise impossible to unearth and can be verified later from various sources. I consider memory-based material a secondary source because it cannot be trusted without cross-referencing.[20] I have archived most of the interviews both as transcriptions (.docx) and as audio files (both .wav and .mp3). Transcriptions are invaluable when one is annotating or browsing the material afterwards. However, they hide certain important aspects: for example, in an audio recording it is possible to hear how the interviewer fills gaps in the interviewee's memory with almost silent gestures – something that cannot be perceived even from an accurate transcription.

1.2.3 The ethical conducting of the research and archiving the project

I informed the research participants about the goal of the study. The goal presented in the agreement extends beyond the scope of this dissertation,

[19] See: https://www.finna.fi/Content/about

[20] For a description of the methodological challenges related to oral history such as interviews see Chapter 3.1.

having been outlined for the broader research project on electroacoustic music history and analysis in Finland. The research group, members of which have access to and the right to use the material as agreed upon, consists of the UHMRL Kurenniemi research group (Mikko Ojanen, Jari Suominen, Kai Lassfolk, and Maiju Jouppi). I have also agreed on the details of how to manage and re-use the collected material in the future.[21]

All the research participants gave their consent to participate in the study under their own name. However, the signed agreement does not relieve the researcher of the responsibility of following the guidelines of research ethics and integrity if the collected material contains details that would be harmful to them or to third parties. If I identify such details in my collection, I anonymize them before making the material openly available. In many cases, however, the anonymization renders the historical information in the sources beyond usability. In such cases, I keep material containing sensitive, confidential or copyrighted information secure, and only open the metadata.

I have set up the data archive community *Electronic Musical Instruments by Erkki Kurenniemi* in Zenodo to facilitate the archiving of the research material after it has been cleaned up for publication.[22] The archive provides the documents with persistent identifiers (digital object identifier, DOI), which ensure the findability, accessibility, reusability and, most importantly, the citability of the material and data. I open all the material I can make openly available in line with the ethical guidelines as early as possible – in some cases even before publication.[23] The research material and data for which I have the right of use, or the right to issue licenses to third parties, are published under Creative Commons Attribution (CC-BY).

1.3 Previous research on the topic

1.3.1 General remarks on the background literature

In some cases, the textual research material and the data overlap with the research literature. Some texts even serve both purposes at the same time. For example, many of Kurenniemi's own texts could be considered primary sources when the focus is on his train of thought, and secondary sources in introducing a contemporary review of the historical situation of electronic music and instrument design in the Finnish context. The question is whether to approach his texts as evidence of his thinking or as research literature on the design of electroacoustic music and instruments. Their value in the former case is unquestionable even if their relevance in the latter is uncertain.

[21] For the content of the agreement, see: Ojanen (2018): https://doi.org/10.5281/zenodo.846985.

[22] See: https://zenodo.org/communities/electronic-musical-instruments-by-kurenniemi/.

[23] See, for example, the Appearances of Kurenniemi's Electronic Musical Instruments: https://doi.org/10.5281/zenodo.842854

To clarify the division into research material and research literature, and to facilitate readability, I refer to the literature primarily by means of in-text citations (the longer reference lists in this chapter are an exception), and to the material in footnotes.

I divided the background literature into three categories according to the role of the text in question as follows: 1) theoretical and methodological background, 2) studies on electroacoustic music (secondary source material and contextualizing literature for the general background), and 3) primary source material. I review the main theoretical and methodological background literature[24] in Chapters 2 and 3. In Chapters 4–8, I use the texts as contextualizing literature for the general background[25] or the primary source material[26]. In the following section (1.3.2) I only review the publications that are relevant as background information on the academic and popular discussion about the electroacoustic music of the 1960s and the 1970s in Finland.

1.3.2 Previous research and publications about electroacoustic music in Finland

Electroacoustic music aroused heated public discussion as soon as the genre appeared in Finland during the late-1950s (see Kuljuntausta 2002; 2008). Academic research on the subject, however, only dates back to the early 1990s. Thus far, studies have concentrated on dating and describing historical events, artists and musical works – not on deeper analysis or cultural contextualization. Moreover, events and circumstances after the 1960s are still broadly unexplored, nor have any of the events been placed in a wider international context.

Only a few reviews[27], theses and seminar papers[28] were written on the subject of electronic and experimental music in Finland before the turn of the

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[24] Geertz (1973), Denzin (1970a; 1970b), Megill (2007), Ginzburg (1989; 1993; 2012), Levi (1991; 2012), Borgmann (1984), Bijker, Hughes & Pinch (2012b) Goehr (2007), Katz (2010), Taylor (2001), Nattiez (1990), Hamilton (2007), Magnusson (2009), Birnbaum et al. (2005), among others.

[25] The main literature for the general historical presentation of electroacoustic music includes Chadabe (1997), Kahn (2001), Collins & d'Escriván (2007), Holmes (2012), and Manning (2013). For localized descriptions I consulted national and studio-based histories such as Wiggen (1972), Born (1995), Glinsky (2000), Kuljuntausta (2002; 2008), Broman (2007), Bernstein (2008), Niebur (2010), Smirnov (2013), Groth (2014), and Patteson (2016).

[26] In other words, contemporary sources on electroacoustic music in Finland. I consider contemporary magazine and newspaper articles to be primary sources and list them under research material rather than research literature.

[27] Lindfors & Salo (1988), Tiits (1990a), Eerikäinen (2007), Ruohomäki (1994; 1998), Heiniö (1995)

[28] Riikonen (1978), Laiho (1982), Laine (1984), Lång (1990), Tiits (1990b), Nikki (1993). Hannu Riikonen focuses on the music of Osmo Lindeman in his Master's thesis for the University of Turku written in 1978. Kalev Tiits' Master's thesis for the University of Helsinki written in 1990 focuses on the music and instrument design of Erkki Kurenniemi, and Tarja Nikki's on the musical theories of Kurenniemi and Jouko Tolonen.

century, and the distribution of information was in the hands of a few enthusiasts – most notably on the webpage pHinnweb[29] (1996–) maintained by Erkki Rautio and the radio program *Avaruusromua* [30] (Space Junk, 1990–2020), produced by Jukka Mikkola for the Finnish Broadcasting Company Yle.

Composer Jukka Ruohomäki (b. 1947) conducted one of the most extensive, mainly unpublished, basic research projects in the early 1990s. He started to collect information on electronic music in Finland in 1993, and he digitized approximately 600 electroacoustic works and other recordings into the DAT collection maintained by the Finnish Music Information Center[31]. In addition to this collection, Ruohomäki produced a four-part radio program *Ihmisiä, koneita ja musiikkia*[32] (1993; Engl. Men, Machines and Music) and wrote two magazine articles (Ruohomäki 1994; 1998).

Ruohomäki's own research project came to a halt when he started his second composition period in 1994. Fortunately, the transcriptions of his several interviews and the large manuscript are at the disposal of researchers. Composer Mikko Heiniö wrote a concise history of electronic music in Finland for the fourth part of the distinguished book series on Finnish music history, which was largely based on Ruohomäki's research material (Heiniö 1995, 182). In 2013, Ruohomäki (2013) revised and published the chapter that presents the electronic music of composer Henrik Otto Donner (1939–2013) as an article in the journal of the Finnish Society for Ethnomusicology *Musiikin Suunta*.

One by-product of this study is the making of Ruohomäki's previously unpublished work openly available. The manuscript[33] has now been published in the research material database of this study, with Ruohomäki's permission. Even though some new source material has been found, as a result of which some of the sections of his manuscript require revising, his work provides an extensive set of research material that I utilize especially in my historical description. Via my study, Ruohomäki's work, written in Finnish, has become accessible to English-speaking and other audiences.

By far the largest piece of published research was carried out by media artist and musicologist Petri Kuljuntausta (2002; 2008).[34] Kuljuntausta's interest in sound art and both electronic and experimental music in Finland started in the mid-1990s when he founded the association *Äänen lumo*[35]

[29] See: http://www.phinnweb.org/.
[30] See: https://yle.fi/aihe/ohjelma/avaruusromua.
[31] Currently Music Finland, see: https://musicfinland.com.
[32] See Ruohomäki's radio program (1993) *Ihmisiä, koneita ja musiikkia*, [men, machines and music]. Yle Archive ID: DIG-390965-0.
[33] See Ruohomäki (2020): *Suomalaisen elektroakustisen musiikin historia [käsikirjoitus] / The History of Electroacoustic Music in Finland [manuscript]*
https://doi.org/10.5281/zenodo.3605511.
[34] It is noteworthy that Kuljuntausta also had Ruohomäki's manuscript at his disposal.
[35] See: www.aanenlumo.fi.

(Charm of sound; 1995–), and hosted the radio program of the same name. The Museum of Contemporary Art Kiasma commissioned an essay on the subject from him in the late 1990s. The work, which started as an essay in 1999, turned out to be a manuscript of about 700 pages that was eventually published as a comprehensive book entitled *On/Off: eetteriäänistä sähkömusiikkiin* (Engl. On/off: From Ether Sound to Electronic Music; Kuljuntausta 2002), with an accompanying CD including 15 tracks of early electronic musical works – most of them previously unreleased. Later on, *On/off* was assessed and accepted as a Licentiate thesis at the University of Jyväskylä. Kuljuntausta's doctoral dissertation, which he defended in 2008, is based mainly on *On/off*, translated into English and published under the title *First wave: a microhistory of early Finnish electronic music* (Kuljuntausta 2008).

Kuljuntausta restricted his study to the early years (1958–1964), although sporadic notes touch upon events in the 1970s beyond his formal temporal framing. He places the historical events within the cultural context but leaves plenty of work to be done to complete the picture, at least from the mid-1960s onwards. However, with the inclusion of exhaustive lists of historical newspaper and journal articles Kuljuntausta's books provide stepping-stones enabling researchers to access contemporary writings from the early years of electronic music in Finland.

Kurenniemi's lifetime work has attracted wide international interest during the past 20 years. The most influential source concerning his role at the dawn of Finnish underground and avant-garde circles comes from outside academia. A major revival of his work was initiated in 2002 by Mika Taanila (2002) in his documentary film *Tulevaisuus ei ole entisensä* (Engl. The Future Is Not What It Used to Be). Two DVD releases followed (Taanila 2003; 2007), which include a collection of Kurenniemi's original experimental short films from the late-1960s and slide shows of his instruments and principles of his mathematical theory on music. As part of the film project, Taanila compiled a CD release comprising eleven tracks of Kurenniemi's electroacoustic works and other recordings (Kurenniemi 2002).

Kurenniemi's work was presented in a series of art exhibitions[36] and in scholarly publications in the 2010s (Mellais 2013; Krysa & Parikka 2015). It is also recognized in the international research community and in popular forums of electronic music (see Collins et al. 2013, 66–71; Hvidlykke 2013; Crab 2015). Kurenniemi and his work have also been introduced in a plethora of blog postings. Even though they popularize the subject and present his work to wider audiences, detailed information is typically defective and simplistic, with no referencing to the primary material or to the origin of the information that is presented.

[36] Documenta13, Kassel Germany, 2012; Kunsthall Aarhus Denmark, 2013; The Museum of Contemporary Art KIASMA, Helsinki, Finland, 2013–14.

Recent interest in Kurenniemi, his electronic music and his musical instruments is reflected in the various publications[37] and the work coordinated by Perttu Rastas at the Finnish National Gallery. The gallery maintains Kurenniemi's personal archives and organizes his instrument-restoration projects and other activities. The international series of his archive exhibits and international book publications are driven mainly by Rastas and his enthusiastic interest in Kurenniemi's work, and the resources of the Finnish National Gallery.

1.4 The structure of the study

Out of respect for the subject of this study, in Chapter 2 I present the technological questions before the musical and aesthetic considerations. History writing (Chapter 2.1) is a common thread running throughout this treatise on technology and music. I do not offer a chronological historical narrative, nor is this study a biography. I present the contents of certain chapters as chronological narratives, but the broad organization of the material is thematic. After giving the historiographical background I introduce the key concepts and theories that shed light on how I address the sociotechnical, musical, and aesthetic questions (Chapters 2.2 and 2.3, respectively).

Given the subject of the study, it is necessary to define technology. In my view it is a cluster of concepts to be defined within the context in which they are used rather than as a single entity. I recognize at least four types of definition (Chapter 2.2.1). I also acknowledge technology as a developing concept, which requires a description of how it changes. In Chapter 2.2.2, I review the key trends in science and technology studies (STS) that are relevant in the context of this work. Most of the concepts I apply derive from the Social Construct of Technology (SCOT) and Actor Network Theory (ANT). Despite their differences, both conceive of technological change as a sociotechnical process in which users and physical artifacts are seamlessly intertwined – both acting and affecting one another. STS-based theories arose as a reaction to linear models of technological development. Even though many of them cry out for major revision, including that for the diffusion of innovations outlined by Everett Rogers (1931–2004), linear models cannot be fully disregarded.

I present the definitions and uses of concepts such as a musical work and the composer (as an author of the work) in Chapter 2.3 on music-history writing. I associate such writing with the definition of a musical work, which I contemplate in the sub-section on aesthetic theory (Chapter 2.3.2). It is

[37] See Korhonen (2002); Ojanen & Suominen (2005); Ojanen et al. (2007); Väkiparta (2007); Yli-Annala (2007); Taanila (2007); Uimonen (2007); Tiekso (2013; 2016); Suominen (2013); Lassfolk (2012; 2013a); Ojanen & Lassfolk (2012); Ojanen (2013; 2014a; 2014b; 2015); Lassfolk et al. (2014; 2015); Niemelä (2019); Kuljuntausta (2020) Karjalainen & Kärki (2020).

necessary to define the concept of a musical work, especially in the field of electronic and experimental music. From aesthetics I find the ideas presented by Demers (2010) useful. Even though she addresses her questions to a notably more recent period in the history of electroacoustic music than I do, my attitude towards the interdisciplinary nature of the topic is close to her descriptions.

In Chapter 3, following the same order, I present the methodological toolbox I use in the succeeding analyses. First and foremost, I tune my methodological instrument to be historically sensitive. I see a strong resemblance between the methods I employ and qualitative research and content analysis, for example (Chapter 3.1). Chapter 3.2 presents the concepts and tools of the research on digital musical instruments (DMI), which I apply to Kurenniemi's case. Music analysis in the electroacoustic music domain deserves its own presentation (Chapter 3.3), although I see many analytical similarities between the use of musical instruments and musical works.

Writing a global history of electroacoustic music is not within the scope of this study. However, given that previous research has not contextualized the state of electroacoustic music in Finland, and to facilitate understanding of how the phenomenon emerged, I review the global perspective on the key developmental lines in Chapter 4. I also trace the preconditions of its emergence, and describe developments in sound recording and technological processing, as well as in electronic musical instruments and music aesthetics and styles in both high art and popular genres. In addition to considering global developments, I outline the historical context of electroacoustic music in Finland at the turn of the 1960s, before Kurenniemi started to envision his designs.

In Chapter 5 I review the history of Kurenniemi's instrument-design projects, including that of the University of Helsinki Electronic Music Studio, focusing on those *who used his instruments*. I present the key features of the instruments in Chapter 6, which have already been described in previous research, hence their internal structure on the component level is beyond the scope of this work. I rather emphasize user interfaces and usability issues. Chapter 7 comprises user stories about Kurenniemi's electronic musical instruments, as told by both Kurenniemi and his collaborators who used them. This chapter contains the main analyses of the study and elaborates on *the usage of Kurenniemi's instruments*.

The discussion in Chapter 8 summarizes the findings of the analytical sections in light of the academic discussion in earlier chapters. I also outline the frameworks and categorizations as an outcome of this dissertation. Lastly, in Chapter 9, I assess the chosen toolbox and contemplate how it works with regard to the questions I ask and the material I present in this study. I also look into the future and suggest a few threads of research that could be potentially fruitful.

The most important task for the future is to continue the work on preserving our rich cultural heritage, which will vanish if actions are not taken in the very short term. Information, research material and data related to electroacoustic music are scattered around the institutional archives, private collections and other miscellaneous locations. Collectors – in some cases even responsible organizations – may not be aware of either the significance of their sets of material or the possibility to deposit it in repositories maintained by responsible organizations. Significant collections have already been destroyed due to the lack of archive space among both private collectors and memory organizations. As a concrete spin-off from this study, I have set up The Finnish ElectroAcoustic Research Sources (FinEARS) project to answer this call.

This study includes several references to sources originally in Finnish or Swedish. Unless otherwise mentioned, I have translated the quotations into English myself. In addition, to clarify the division into research material and research literature and to facilitate readability, I refer to research material and data in the footnotes and to research literature in in-text citations.

2 THE CONCEPTUAL AND THEORETICAL BACKGROUND

On the conceptual and theoretical level, I concentrate on writing the history of music technology. The three general themes – history, technology, and music – have their own established disciplines. Thus, this study is multidisciplinary in nature. The aim is to discuss controversial concepts that seem to be constantly under debate among the scientific community. In many cases the different approaches are complementary and not exclusive. The various disciplines contextualize phenomena in different wording, and the academic contentions reflect the different targets of the arguments. I do not aim in this theoretical review to develop new solutions to conceptual and theoretical questions that are still under discussion, I merely describe on what grounds my work is based.

My descriptions may be overly simplified, but I seek agreement. According to the present paradigm, qualitative research should be quantitatively enriched, and vice versa. In a similar way, the interpretative orientation relies on basic research or "facts" (see Hobsbawm 1998, viii), although some postmodernists are ready to jump straight into metanarratives and to disregard the painstaking "archival work, the documenting of primary sources and theoretical pondering." (Mantere & Kurkela 2015, 5–6; see also Rahikainen & Fellman 2012, 1–3). According to Carr (1986, 24):

> *"[t]he historian and the facts of history are necessary to one another. The historian without his facts is rootless and futile; the facts without their historian are dead and meaningless. My first answer therefore to the question, What is History?, is that it is a continuous process of interaction between the historian and his facts, an unending dialogue between the present and the past."*

Carr's description is akin to defining the target of musicological research or music analysis. The musical work as a material trace of its producer's poietic process does not carry a meaning in itself, but without it the receiver is devoid of an esthesic process (see Nattiez 1990, 15).

There is a need both for basic research and for far-reaching analytical metanarratives – and the latter should be based on the former. In this chapter I outline the overarching background concepts that can be detected in history writing, technology studies, and aesthetics, and then I review the theoretical background of the key themes in separate sub-chapters.

A concept that serves as an intangible guideline, and that repeatedly emerged when I was reviewing the theoretical and methodological literature concerning the key themes, is *thick description*. It was initially formulated by Gilbert Ryle, and then further developed by anthropologist Clifford Geertz (1973, 5–10). Geertz uses thick description to exemplify how human behavior should be analyzed in its context – not merely described. He refers to Ryle's classic example of the problem of interpretation with regard to human behavior. Ryle exemplifies the issue with a detailed description of the different meanings that could be attached to the contraction of an eyelid: he distinguishes a twitch from a wink, a wink from the faking of winking, and so on (ibid. 7).

Thick description has been widely adopted as a general tenet in different fields of science. Authors concentrating on describing a historical event (see Burke 1991b and Levi 1991), studying a technological artifact (See Bijker 1995 and Bijker & Pinch 2012), or analyzing a musical work (see Tomlinson 1984) seek to thicken their descriptions – quite often with an implicit mention of the concept, but also with a literal reference to Geertz. In the field of technology studies, for example, Bijker (1995, 9–10) calls for a balance between contextualized and detailed "nuts and bolts" levels of analysis. Thick description also resonates with the concept of the seamless web outlined by researchers in the field of Science and Technology (see Chapter 2.2). Nattiez (1990) considers all three, the musical work in its material reality, in other words the "nuts and bolts" level, the producer's poietic process and the receiver's esthesic process as necessary parts of musical analysis. There is a plethora of similar examples in history studies.

Whereas there is a solid consensus among scholars on the matter of thick description, a few other background concepts seem to be oxymoronic. As an example, the contention between *objectivity* and *subjectivity* colors several discussions about the nature of scientific knowledge – especially epistemological issues. Objectivity has traditionally been among the cardinal virtues of the scientific paradigm. In a historical presentation, for example, the historian is required to avoid anachronism, presentism, hindsight and teleological explanation. Yet at the same time it is acknowledged that history is written from the current perspective by a present-day author, whose subjective attitudes affect the process. In other words, historians writing history with a distinctive voice from the present are obliged to detach themselves from the here and now, even from their own personal opinions.

Another pair of general concepts whose role in epistemology is disputed is the *descriptive* and the *analytic*. These research frames are considered contradictory in various fields, but they do not need to be. Most notably, the segregation between the analytic and the descriptive appears in historiography when historians argue about what their discipline should concentrate on - the chronological narration of events or analyses of the structures and circumstances. I argue that there is a need for descriptions of what happened and for overarching analyses of the underlying structures.

A few shifts in focus in the Social Sciences, Humanities, and Science and Technology during the past 100 years are also worth mentioning, specifically from the global to the local, in other words from macro to micro, and from society to people. Current research settings also emphasize users alongside engineers, consumption alongside production, audiences alongside composers, women alongside men,[38] and failure alongside success, to give a few examples (see Burke 1991b, 1). As underlying causes of many of these changes Rahikainen & Fellman (2012) identified two pivotal movements in the development of 20th-century academia, namely the *linguistic turn* and the *postmodernist challenge*.

One way of solving seemingly contradictory problems is through concepts such as the *etic* vs the *emic* (see Pike 1967; Geertz 1973; Nattiez 1990, 60–62; Headland 1990; Emmerson & Landy 2016, 18–19). Researchers representing the etic perspective consider the research subject from the outside and employ their own methodological tools and concepts, whereas those adopting an emic stance consider it from within, the categories and descriptions used reflecting the insiders' concepts. Emmerson & Landy (ibid., 18) define these approaches as measurable difference (etic) and significant difference (emic), whereas Collins & Yearley (in Leskinen 2000, 186) describe them as theoretical language and observation language.

The main themes of this study (history, technology, and music) could be considered individual cultures (emic), for example, and my observations on them as from the outside (etic). Distinguishing two levels raises awareness of the concepts and descriptions used to interpret the subject of the study. Oldenziel (2006, 481–482) considers the issue in the context of history and technology studies, claiming that historians of technology "fail to recognize the fundamental distinctions between technology as an 'analytical tool' [etic] and as a 'lived experience' [emic]." For me this became evident when I was considering the terminology I would use to define the subject of my study – my detachment from the original 50-year-old context, from concepts such as electronic music, sound art, the computer, and the (digital) synthesizer, influenced my interpretation of past circumstances, and I pay special attention to the historical definitions.[39]

2.1 History: general remarks on historiography

> *"Histories do not exist in facts, or artifacts, or documents, or archives, or collections, or any other miscellaneous items we may associate with the past. Histories are invented. Historians invent histories by telling stories. The first question a historian asks is: What story do*

[38] Or as Oudshoorn & Pinch (2003, 4) note, the focus has moved from a neutral to a gendered orientation.

[39] See for example Ch. 2.3.3 Definition of electroacoustic music.

I want to tell? And answers that question from the perspective of the present. A historian looks around, notes that something is happening, and asks: How did this come about? A historian then chooses the events, artworks, sounds that are included in the history and interprets those items as significant to the story."

Composer and electroacoustic music historian Joel Chadabe (2005)

Composer Joel Chadabe aptly captures the present paradigm of history writing. However, the citation obscures a contention that persists in the academic discussion. Current history writing does not comprise a coherent set of parallel threads. Writers rather follow several independent trends that foster disagreement among their advocates. Examples include the history of mentalities, microhistory, women's history, history from below, structural history, the history of events, and cultural history, among others (see Burke 1991b; Peltonen 1995; 2002; Sivuoja-Kauppala et al. 2013, 3–4).

Even the most critical historians – perhaps excluding advocates of philosophical skepticism – do not deny that the past happened. The question is not whether or not the past exists, it rather concerns how and what kind of knowledge it can yield. The dispute is about what is considered a pertinent or even acceptable target of study. Thus, the historiographical debate is epistemological rather than ontological (Megill 2007; Torvinen 2007), which has not always been obvious.

The shift towards pluralism in history writing emerged gradually between the 1940s and the 1980s, when the new paradigm challenged objective historiography – so-called Rankean history.[40] During that time there was a strong increase in historiographical methods and in the variety of acceptable source materials. In the words of cultural historian Jukka Sarjala (2002, 28): "Nowadays several different roads lead to the past and they do not necessarily have anything in common." Due to the paradigm shift, the scientific community abandoned its conception of the past as something that could be objectively reconstructed. It does not exist as something "fixed and static waiting to be described", but the past (or our comprehension of it, to be precise), the present, and the future are all in constant interaction with and perpetually defined by one another (Goehr 1992, 183; see also Carr 1986, 24).

Despite the plurality of modern trends, there are a few common principles. According to Burke (1991b, 2–6), at least the following five traits are common to several historiographical trends of the late 20th century. 1) Traditional history writing in the 19th century concentrated on politics, the state, the church and war, whereas the new trends acknowledge that "everything has a history". 2) History was traditionally accessed "from above", from the perspective of the "great deeds of great men", whereas the new history writ-

[40] Rankean history refers to a tradition started by German historian Leopold von Ranke (1795–1886).

ing accesses the past "from below", from the point of view of ordinary people. This has a strong resemblance to the *symmetry principle* in technology studies, which holds that both successful and failed projects should be studied using the same terminology (see Chapter 2.2). 3) Rankean history was based on official documents maintained in official archives, whereas the new traditions accept a greater variety of source material such as visual, oral, and statistical. 4) Rankean history concentrated objectively on relating "how things actually happened", whereas during the 20th-century researchers acknowledged that (cultural) relativism affected both the process of historical writing and its object.[41] 5) Finally, historiography was gradually professionalized at the beginning of the 20th century, but later the emphasis turned to interdisciplinary connections and history has been written outside the professionalized framework. I return to this in my discussion about the writing of music history (see Chapter 2.3.1).

The historian approaches the past from the current perspective through surviving contemporary documents. Events in the past can be positioned with a certain precision but the causal relationships between them are ambiguous. Even the most comprehensive series of historical sources provide only fragmented documentary evidence. Moreover, listing dates as a chronological timeline rarely produces anything other than a hollow collection of consecutive notes in a calendar. Therefore, the historian must interpret both the fragmented documents and the gaps in them to understand the past. It has been claimed, however, that any interpretation depends on the attitudes, opinions, intentions, age, sex, and social class of the writer, among other things. Even the process of selecting a subject of study has been debated and considered a political question (see Rojola 2001; Megill 2007, 214–215; Moisala & Seye 2013, 39).

Dividing the target of historical research into 1) the past per se, 2) the various experiences of contemporaries, 3) the surviving documents, and 4) the historian's interpretation of these documents facilitates understanding of the perspectives from which the issues have been approached. Music philosopher and historian Carl Dahlhaus (1983, 11) outlined a similar division with reference to 19th-century historians such as Droysen and Ranke, who "distinguished between a 'reality' that remains in part unaccounted for even after the most stubborn efforts have been made to reconstruct it, and a 'truth' of history that imparts sense and structure to what are otherwise mere accumulations of facts." Disagreements in academic communication often arise from

[41] The question of relativism is complex. In short, historiographical approaches can be distinguished by their stance on epistemology – on other words whether they focus on the past itself, on the interpretation of the past or on the research method used. Otherwise, seemingly consistent approaches may differ in whether they are relativist or anti-relativist in nature. See, for example, Levi's (1991) detailed comparison of Italian microhistory and Geertzian interpretive anthropology. Furthermore, it seems that Goehr (1992) subscribes to the relativist stance in history writing, whereas Levi (1991) and Ginzburg (1993), for example, "refute relativism" in their approaches. See also Hobsbawm (1998, viii) who stresses that "what historians investigate is real."

the failure of the debaters to recognize to which of the four above-mentioned targets they are referring.

The past happened in the chronological order of parallel and consecutive events. However, people experience these strings of events uniquely, and contemporary historians do not have direct access to the events or the experiences (see Gaskell 2001, 187–188; 210; Megill 2007, 17–40; 213). Events are attached to each other via intangible causal pathways. Culture, society, politics, economics, and so on could be considered hidden structures that reveal themselves through the events, but only through the events and only partially. The past per se is gone and it cannot be caught or changed. Events and chronology provide only a fragmented framework. Historians looking backwards are able to grasp only one presentation of the past at a time, which is filtered by their detachment from it. They should be conscious of these filters, whether they be related to their own political agendas or to other aspects of research such as materials, data, interviewees' opinions, methodological dilemmas or theoretical issues.

Pinch & Trocco (2002a), who studied the history and impact of an analog synthesizer, namely the one designed and built by Robert Moog and his company, highlight one of the problems related to historical interpretation when they describe their point of departure in the writing of history. They avoid hindsight by describing a historical situation in terms of "what it was like back then, before anyone knew what it would be like now" (ibid., 11). Avoiding hindsight is necessary to ensure transparent interpretation. Pinch and Trocco were aware of the problematic nature of the process, acknowledging that having "filtered stories to bring out certain themes" they "have muted others" and if they "had chosen another configuration of quotes" they "could have produced a rather different history" (ibid.). By avoiding hindsight, they aimed to satisfy the oxymoronic demands of the simultaneous objective and subjective perspectives.

Burke (1991a, 239) also emphasizes the importance of interpretation, stating that researchers should make themselves visible in their presentations and warn their readers that the presented interpretation is only one of many. Megill (2007, 1–3), in turn, stresses the role of transparent argumentation in history writing. By way of clarification he introduces the term *unresolving tension* or *unresolving dialect*, meaning that "a true historian is happy to leave her mind suspended between conflicting attitudes or claims." According to Megill, "it is not the historian's task to articulate a single unequivocal position, let alone a single consistent theory, concerning the world as it is" (ibid.).

Along with the epistemological questions, the focus and form of history writing have been debated. Historiographical presentations have been written as narratives, which are distinguished from literary narratives. According to Italian microhistorian Carlo Ginzburg, the difference between the two is in the way the authors approach the reality through the fragmented documentary evidence. As he points out, "the obstacles interfering with research in the form of lacunae or misrepresentations in the sources must become the part of the account". In other words, the historian must transform the problem of discontinuous sources into a narrative element, whereas the literary narrator can leap "over the inevitable gap between the fragmentary and distorted traces of an event and the event itself" and thus "tacitly remove constituent limitation of the historical profession." (Ginzburg 1993, 28)

Historians who stress the narrative approach tend to emphasize the importance of events as the subject of research, whereas critics focus on the structures and emphasize analysis over mere description (Burke 1991a, 233–234). One spike in the debate was triggered by Lawrence Stone's (1979) controversial article "The revival of the narrative", in which he criticizes many of the new historians who were returning to the storytelling mode of history writing. The problem according to Burke, however, was not whether historical presentation should be written in a narrative form: on the contrary, it has been acknowledged that even analytic presentation focused on structures necessarily takes a narrative form of some sort. (Burke 1991a, 233; see also Megill 2007, 11)

Stone acknowledged in his original article that historians have "always told stories". His primary concern was the development in history writing to concentrate on "man not circumstances" and to deal "with the particular and specific rather than the collective and statistical" (Stone 1979 3–4). He feared that descriptive story-telling – for its own sake – about obscure, poor and atypical people marked the end of "the attempt to produce a coherent scientific explanation of change in the past" (ibid., 19–23).

Even though Stone's juxtapositions capture the main differences between the paradigms of the complete history of the early 20th century and the more recent developments within cultural history, his critique was mainly targeted at Italian microhistory, which has attracted wide interest during the 35 years of its existence. The trend, which was new at the time when Stone was writing, has mainly been associated with Carlo Ginzburg and Giovanni Levi, even though the term *microhistory* appeared in a few historiographical publications in the 1950s and 1960s (see Ginzburg 1993, 10–12). Of the new postwar trends in historiography I give more detailed attention to Italian microhistory because it is widely referred to in Finnish writing on music history from the past ten years – and specifically with regard to electroacoustic music (see e.g. Kuljuntausta 2008; see also Sivuoja-Kauppala et al. 2013 and the collection of articles in *Musiikki* 3–4/2013, Toivakka 2015 and Reimann 2015).

It is noteworthy that the turn from the macro to the micro is not a unique feature of history writing, there having been a similar gradual shift of focus in economics and sociology between the 1940s and the 1960s (Peltonen 1995; 2002). The turn to examining relationships between the larger structures and their constitutive elements also came to be recognized as the essential premise of structuralism[42] and post-structuralism[43]. Within the field of the present study, it is worth pointing out that Dahlhaus (1983, 8) also used juxtapositions such as great men/great works vs. the masses/the rest in music history writing as early as in 1977. Thus, several independent but parallel threads developed during the 20th century, which Ginzburg (1993, 28) acknowledged, stating that their "researches were a fragment of a more general tendency." Moreover, even microhistory can be divided into the old and the new. Thus, to use microhistory as a label without reflecting its multifaceted concepts and tools in the research questions and material is to oversimplify the matter, and to restrict description of the trend to the concepts of micro and macro is superficial.

Ginzburg (1989, 96–102), who studied the "silent emergence of the epistemological paradigm in the late 19th century", introduced the key microhistorical concept, *clues*. He noticed striking similarities in the methods of Giovanni Morelli (detailed pictorial marks), Sigmund Freud (traces or symptoms), and Sherlock Holmes (clues). According to Ginzburg (ibid.), all three were linked to medicine, in other words to a "discipline which permits the diagnosis of diseases inaccessible to direct observation based on superficial symptoms." He thereby likens historical knowledge to the physician's knowledge: both are indirect, presumptive and conjectural. "The reality is opaque, but through signs and clues it can be penetrated" (ibid., 123). Peltonen (2002) points out that the concept resembles pre-microhistory trends in the academic literature, suggesting that clues can be likened to Michel de Certeau's concept of *margins* and Walter Benjamin's notion of *monads*. From the micro-historical perspective, clues are mismatched details in research material. As Peltonen (ibid.) put it, they are "something that do not quite fit, something odd that needs to be explained."

Another essential concept in micro-history alongside Ginzburg's clues is *the scale of observation*, which Levi (1991, 97) describes as "the unifying principle of all microhistorical research". Reduction of the observation scale facilitates the use of microscopic clues to reveal larger, hidden structures and previously unobserved factors. In this respect, the micro-historical approach aims at a holistic understanding of large historical structures (Peltonen 2002, 349–50) rather than merely describing the research material in microscopic detail. Hobsbawm (1980, 7) responded to the discussion in 1980:

> *"there is nothing new in choosing to see the world via a microscope rather than a telescope. So long as we accept that we are studying the same cosmos, the choice between microcosm and macrocosm is a matter of selecting the appropriate technique."*

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[42] Related to the early-20th-century linguist Ferdinand de Saussure (1857–1913).

[43] Related to philosophers Michel Foucault (1926–1984) and Jacques Derrida (1930–2004).

Levi (1991, 96–97) made a similar point a little later, referring to *thick description*, suggesting that the reduction in scale, specifically in the micro-historical approach, allowed the adjustment of observations for experimental purposes. On the one hand, the scaling could be likened to thick description in its inductive starting point and in its concentration on the detail and the context. On the other hand, it is also in line with Hobsbawm's comment about the scale not being fixed but being adjustable in relation to its target. The key point here is how adjusting the scale influences the interpretation. As I show in this study, the static scaling of observations in previous studies has influenced – even skewed – descriptions of how electroacoustic music developed in Finland during the 1960s.

To exemplify the effect of the scale of observation and the outlining of the thickness of the descriptions even further in the context of this study, let us consider statements about continuity and discontinuity in the early history of Finnish electroacoustic music. Several writers agree that the early years fall into two periods (see Lång 1990, Ruohomäki 2020; Kuljuntausta 2002; 2008). There seems to have been a period when activity in this field was at a stand-still for some years – at least judging by the number of completed musical works and the amount of concert activity. Whether the hiatus between active periods started immediately after 1963, somewhat later in the 1960s, or even at the turn of the next decade depends on the writer and the set of musical works and composers under scrutiny. However, few attempts have been made to describe what led to this dynamic development and how it manifested itself during those years. I argue that the division into two periods is a product of later interpretation, clearly directed by the scale of observation. It is clear from an even more detailed examination that there was no hiatus in the history of electroacoustic music in Finland during the 1960s.

In addition to clues and scalable observation, micro-historians use the concept of *typical exception*.[44] The term is rooted in a conflict between quantitative research orientations and historical case studies. Historians have traditionally sought typical features in individual cases: whereas events are not repetitive phenomena that could be quantified, individual events are exceptional. With their concepts and tools, micro-historians aim to describe the typicality of exceptional events and circumstances, and to overcome the contention between different approaches (Ginzburg 1989, 96). I consider Kurenniemi a typical exception. Depending on the scale of observation, he appears to be exceptional (on the local level in Finland) or typical (on the global level in Western culture). With this interpretation I exemplify the relativeness of history writing: I avoid hindsight and accept unresolved tension in my detached description of the past. In my view, understanding of the past is dynamic and open-ended, not static and definitive.

[44] Also, exceptional normal (see Peltonen 2002, 348).

2.2 Technology: theories and definitions

> *"Technology is also an environment in which we experience and think about music; it is a set of practices in which we engage in making and listening to musical sounds; and it is an element in the discourses that we use in sharing and evaluating our experiences, defining, in the process, what music is and can be."*
>
> *Musicologist Paul Théberge (2001, 3)*

The scientific community has debated the definition of technology for decades. It is acknowledged that unifying the use of the concept is impossible (see Bijker & Law 1992, 202; Lemola 2000a, 10; Oldenziel 2006; Magnusson 2009). As Bijker & Law (1992, 202) state, "many recent studies have avoided a specific definition of technology". Magnusson (2009, 43–45), in turn, refers to technology as "a phenomenon resisting definitions". It has been approached from several research orientations and from different points of view over the decades – from philosophy and history studies to the natural sciences, and from engineering to sociology and art studies, to name a few. Technology has been defined within the premises of the discipline in question, therefore it can only be understood when it is contextualized.

Not only do the various definitions of technology influence academic research, they have also become inseparable from common parlance and policy-making. Many mundane conversations include profound assumptions on how technology acts, what effects it has, and how people react to it. It has the potential to direct people's assumptions and attitudes, even their decision-making, and it has become a key concept through which people can identify and define themselves (see Haring 2007, 6). For some it is a basis for living, or even gives meaning to life. The medium has become the message (McLuhan 1964). Value judgements concerning technology are ubiquitous. As Oldenziel (2006, passim.) states, it has the power to frame social realities. Despite its ambiguous nature, however, some researchers encourage the routine use of technology just "as we use the words 'sociology' or 'psychology'" (Magnusson 2009, 44).

Careless use of the word is deceptive, however. Any attempt to define technology in more detail reveals a complex web of related meanings, historical developments, and various stakeholders. It is neither possible nor necessary at this point to include an in-depth review of the various definitions in the literature. In the following, therefore, I discuss the key approaches I employ in this study in some detail. For an excellent overview of the historical development of the concept, see Magnusson (2009, 39–77), for example.

2.2.1 Definition(s) of technology

How technology is defined has a fundamental effect on the description of technology-driven music-production processes, just as the definition of *music* or a *musical work* has its effect on music analysis and how the role of music is understood in society. Considered in detail, technology as a concept may be helpful in explaining and analyzing aspects such as culture and society – not unlike concepts such as *canons* and *canonization* in the writing on music history (see Chapter 2.3.1). Here, I see technology as a cluster of concepts. Using the word activates the conceptual structure in which technology manifests itself through several other concepts on various hierarchical levels with various degrees of concreteness. I recognize four levels of technology – the list is not definitive.

First, technology is associated with artifacts such as devices, instruments, and machines realized as either software or hardware, as well as with knowledge of how to design and use these artifacts. It is helpful to distinguish the tools from the practice, in other words equipment from its design and use. In this sense, I consider *technology* a counterpart to *technique*. My distinction between technology and technique differs from those suggested by Elster (1983), Voorvelt (2000), Taylor (2001), and Arrasvuori (2006), for example. Lemola (2000b) uses *technique* and *technology* as synonyms or interchangeable terms, and the word technical has been used in a somewhat similar fashion, such as by Elster (1983) in *Explaining the Technical Change* and in several contributions to Science and Technology Studies (STS) including *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Bijker & Law 1992) and *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Sociotechnical Change* (Bijker 1995). In the present study, on this first level I use technology to refer to *technological artifacts*, in other words the instruments and studio equipment used in the process of music production and composition, whereas *technique* refers to the design and use of these artifacts. *Technical* is a broader term that merges *technology* and *technique* – and blurs the distinction.

The *technology–technique* dichotomy is also helpful when it comes to the diverse types of knowledge involved in these processes. In the current context, expertise is akin to *declarative knowledge* about instruments and equipment (technology), and *procedural knowledge* refers to the design and use of the instruments and equipment (technique). The former is generally more explicit, whereas the latter is tacit knowledge. It is also worth pointing out that knowledge embeds gradually in technological artifacts. More knowledge is encoded into the technology per se nowadays than 60 years ago. For example, a single integrated circuit and microprocessor can perform more diverse and complex tasks than previous constructions with discrete circuits; libraries for microcontrollers developed and distributed within peer-to-peer networks and preset setups in signal-processing equipment, even with pedagogical potential, have all accumulated technological knowledge and memory (see also Chapter 3.2).

Second, technology also refers to institutions and organizations that are involved in its research or development, which with their resources play a particularly significant role in the process of researching and developing technological artifacts. The level of resources and the state of the infrastructure have a significant effect on the design process, even though they do not in themselves explain its effectiveness.

Third, technology could be defined as an inseparable part of society, an outcome of societal activity. From this perspective it has been questioned whether society and technology can be distinguished from one another (Bijker & Law 1992, 201). Scholars engaged in Science and Technology Studies (STS) employ the concept of the *seamless web* to emphasize how tightly intertwined science, technology, society, culture, and economics are (Hughes 1986; Bijker & Law 1992, 201; Bijker 1995, 6 and 15; Bijker & Pinch 2012, xvii). Michel Callon introduced the concept in 1980, and it is aptly described by Hughes (1986, 284–287):

> *"--- [B]oth science and technology are socially constructed cultures, and that the boundary between them is a matter for social negotiation and represents no underlying distinction --- Michel Callon, the French sociologist believes that 'the fabric has no seams'. Callon asks why we categorize, or compartmentalize, the elements in a system or network 'when these elements are permanently interacting, being associated, and being tested by the actors who innovate?'"*

Fourth, on the most abstract level technology is defined in terms of Heideggerian metaphysics related to the *understanding of being*, and as a mode of human existence. It is thus described as a frame that defines all human thinking in every area of life (Heidegger 1994[1953]; Lemola 2000a, 10–11; Torvinen 2007, 12, 127; see also Théberge 2001, 3). *Technology* is powerful as an analytical tool only when it has been anchored in a certain set of definitions. I identify all four types of definition in this study.

2.2.2 Theories of (socio)technical change

Regardless of the definition, technology is not static but requires description of its change and development. How does it change and develop? From where does it originate? The concepts *invention* and *innovation* are relevant here, especially with reference to technological artifacts. Innovations are not necessarily physical objects and could be processes or abstract conceptual structures (Bijker 1995). On the other hand, many scholars describe the development of technology as a series of subsequent events, which are possible only if certain *preconditions*, in other words ideas, inventions, and innovations, have been met or realized (Marx & Smith 1994, x; Théberge 2001, 3–5; 2004, 760).

Fagerberg (2006, 6) distinguishes an invention from an innovation: invention is only "the first occurrence of an idea for a new product or process while innovation is the first attempt to carry it out in practice". This division is widely recognized. According to Gille (in Magnusson 2009, 78), "innovation is invention applied and incorporated into society." In the context of musical instruments, Théberge (1997, 50) states that "an instrument is never really completed at the stage of design and manufacture at all - - - an 'invention' only becomes an innovation once it has been put into the hands of users". In many cases the distinction between invention and innovation may be ambiguous. At the very least, a certain amount of time between the two stages has to be assumed. In fact, anyone can come up with an invention anywhere, within or outside the scientific community, but turning it into an innovation requires resources from the person or the organization to ensure its implementation. (Fagerberg 2006) The distinguishing of two stages is of significance when it comes to analyzing the development and design of Kurenniemi's instruments, which mainly remained in the initial prototype state.

US communication theorist and sociologist Everett Rogers developed one of the most influential theories of innovation. *In Diffusion of Innovations* (1983) he acknowledges time as a necessary component in the diffusion process. He does not explicitly distinguish *invention* from *innovation*, even though similar stages can be assumed from his model. He also identifies different *types of adopters*, *communication channels* and *social systems* as key components in the process. Diffusion theories inspired by Rogers distinguish between the technical and the social, which could lead to a problematic situation in which technology has "an existence which is somehow independent of humans". Diffusion theories are also based on the assumption that there are special discoverers or inventors who bring new technologies to light for the rest of humanity. Once the invention "has been pointed out to people, it is simply a matter of time before everyone recognises it as being obvious." (see McMaster et al. 1997, 72)

The innovation process is typically described as a *linear model*. An engineer or designer first invents or discovers a new solution or device. The invention or discovery is then developed into an innovation, and after that the finished product is ready to be marketed and distributed to consumers. Bijker (1995, 7) exemplifies the process in his traditional six-stage model of a linear innovation process (see Figure 1), although "the number of developmental steps assumed in these models seems to be rather arbitrary" (Pinch & Bijker 1984, 405; 2012, 16–17). The origin of the linear model is unclear (Godin 2006, 639).

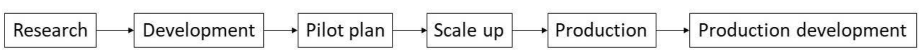

Figure 1. A linear model of the innovation process, as in Bijker (1995, 7)

Science and Technology Studies (STS; see below) approaches criticize the linear model as merely a teleological explanation of (socio)technical change, pointing out that there are many competing solutions in the process, which cannot be assessed based only on a description of the winning outcome. Here again, the *scale of observation* influences the assessment of the situation, and the model cannot be entirely neglected. In certain cases, a linear model can depict the stages adequately, whereas on another level it fails to explain the development process. Thus, its explanatory power depends on the scale on which the design process is observed.

The linear routine of turning an invention into an innovation via prototype testing – first in a laboratory setting and then with users – may help to explain the success or failure of a project when the focus is on the design process of a certain artifact. For example, according to Hannu Viitasalo, Kurenniemi's key engineer and designer in his Digelius Electronics Finland company, they did not "lab" the designs far enough in Digelius.[45] Viitasalo's Finnish colloquial expression "lab" (Finn. "labrata") refers to testing prototypes in a laboratory environment even before pilot-testing them with users. The lack of a systematic routine explains the state of Kurenniemi's design process. On a detailed level, the designer needs to go back and forth between ideas when searching for an effective solution: on a more general level, the prototype and pilot testing require systematic steps – in other words consecutive linear action. It is noteworthy that Viitasalo's assessment of their process was in hindsight in that the systematic model for prototype and pilot testing was not at the disposal of small-scale, DIY-based technology enterprises in the early 1970s – at least not at Digelius's disposal.

From another perspective, the researcher studying technological change locates him- or herself in the grid of *technological determinism–indeterminism–voluntarism* (see Marx & Smith 1994, xii–xiii; Niiniluoto 2000, 29–30; Taylor 2001, 26–38; Katz 2010, 3). The distinction is based on the question of whether technology has a course of its own that directs human activities, or whether people have a chance to change the course of the technological development.

Advocates of *technological determinism* claim that technological change has a pace of its own, and a course that people cannot change. Technological determinism emerged gradually to explain what happens when innovations generate problems that require new solutions. In deterministic terms such a development is also described as a *technological imperative*, meaning that if an innovation is feasible, it will be executed. Continuous technological development, therefore, is beyond human control. (see Niiniluoto 2000, 29)

Sociology-based approaches have been challenging the deterministic view since the 1980s, subscribing to the *indeterministic* or *voluntaristic* perspective. The key advocates who rejected the linear and deterministic views came from Science and Technology Studies (STS) – representing approaches such as the Social Construction of Technology (SCOT; see Pinch & Bijker 1984), Actor Network Theory (ANT; see Callon 1980; 2012; Latour 1987; Law 2012),

[45] Viitasalo (2015), in an interview with Ojanen & Suominen.

and Large Technological Systems (LTS; see Hughes 1994; 2012) (Bijker 1995, 6; Bijker & Pinch 2012, xiv). The main point within these approaches is the consideration of technology as a socially constructed system. As Bijker & Pinch (ibid., xv) remark, “these three approaches did not completely represent the state of ‘new’ sociology of technology”, and there were also other contributions such as feminist studies of technology (Bijker 1995, 6; Bijker & Pinch 2012).

The three above-mentioned STS approaches can be described in combination even though they differ in detail. The common theme is that they “put technology on the agenda of social studies in the first place” (Bijker & Pinch 2012, xvi). They also point out that theories of sociotechnical change should be *symmetrical* without *linear assumptions*, and that an *agent* or *agency* – “one that acts or exerts power - - - [or] something that produces or is capable of producing an effect - - - [or] the capacity, condition, or state of acting or of exerting power” (Merriam-Webster 2019[46]) – has to be added into the descriptions. (Bijker 1995, 13–17)

Under the *symmetry principle* in STS, both successful and failed projects should be explained using the same terminology. According to Staudenmaier (in Bijker 1995, 7), however, only nine papers in the first 25 volumes of the journal *Technology and Culture*, that is from 1960 to 1984, described failed technologies. Bijker (ibid.) describes this as indicative of the view that its success serves to explain the working of the artifact. STS approaches insist that the success or failure of a technological artifact is not a cause (explanans), but an effect (explanandum) or outcome of the process of implementing the technological artifact in practice (ibid.; see also Borgmann 1984, 17–22). As Pinch & Bijker (1984, 405–406) state, “[t]he success of an artifact is precisely what needs to be explained”, not something that explains its working. The symmetry principle can be compared with the turn to studying marginal and “poor and atypical people” in modern history writing.

Social and political theorist Jon Elster identified “two approaches to the study of technical change --- *rational goal-oriented activity* [and] --- *the process of trial and error*” (Bijker (1995, 13). The goal-oriented approach leads to a bipolar description of the technological design process in which the value of the technological artifact is based on a simplified assessment: achievement of the goal is assessed in terms of the functionality of the technological artifact. The device either does or does not work as designed. However, such bipolar assessment is challenged when the technological artifact is used in a creative setting. It is possible to enrich the description of the process using concepts such as *relevant social groups*, *interpretative flexibility*, and closure, which were developed within the SCOT approach as a reaction to the linear models of technological development.

[46] See Merriam-Webster keyword entry Agent in: https://www.merriam-webster.com/dictionary/agent (Retrieved on September 17, 2019).

The concept *interpretative flexibility* refers to the "radically different and competing meanings of a technology" among *relevant social groups* in the initial developmental stages of the novel innovation (Pinch & Trocco 2002b, 67). These relevant social groups aim for *closure* such that one meaning of the technological artifact is eventually adopted and its use is stabilized. Bijker and Pinch exemplify the mechanism of *interpretative flexibility* and *closure* with reference to the early stages of bicycle development. Different features of bicycles – such as a higher or lower front wheel, air-filled or hard tires, a faster or safer model – were differently valued by the relevant social groups using them. Bijker and Pinch go on to describe how the development of the modern bicycle model, which eventually stabilized, was not straightforward and linear, it was a random process driven by the various expectations, anticipations, hopes and needs of the potential users. (Bijker 1995; see also Pinch & Bijker 2012)

Whether or not one believes that closure has been reached depends, again, on the *scale of observation*. A certain form of interpretative flexibility may re-emerge once the technological innovation has stabilized. At any point in the artifact's life cycle its users can re-define the meaning of a technological artifact and produce use cases that the designer could not possibly have imagined on the initial level of invention. Whether these local re-inventions could challenge the technology on a larger scale depends on the maturity of the system. Here, US historian of technology Thomas P. Hughes (2012) elaborates on the description of technological change, emphasizing the potential effect of the size and age of the system on it. Older and larger systems are less open to change driven by outside influence than younger and smaller systems, which are still vulnerable. The technology of electronic musical instrument design was in its infancy in the 1960s, and prone to change.

2.2.3 The role of agency in the designer–artifact–user interaction

Despite the parallel perspectives on sociotechnical change, there are some major differences in the STS trends. The key difference between SCOT and ANT, for example, is in the background: ANT is based on semiotics whereas SCOT originated in sociology. Bijker & Pinch (2012, xviii) caution against conflating the concepts from these frameworks precisely because of the background differences. According to Leskinen (2000, 186), "ANT is not suitable in sociological explanation."

The specific discrepancy between ANT and SCOT concerns the role and location of agency. In the ANT context, according to Callon and his collaborators French philosopher and sociologist Bruno Latour and British sociologist John Law, descriptions of actor networks should be symmetrical: in other words they should not make an "ontological distinction between human and nonhuman actant". From the SCOT perspective, on the other hand, agency cannot be associated with nonhuman network components (Bijker & Pinch 2012, xxii). It is worth noting here that the ANT approach does not assume "intentionality in artifacts nor mechanism in humans", as Leskinen (2000, 186) points out, referring to Callon and Latour who state that their approach "does not take a stand on the difference between human and nonhuman but leaves the question unanswered."

The term actant is used in ANT to emphasize that the word *actor* (orig. French acteur) is not restricted to individual human actors with intentions but also includes the Greimasean[47] *actant*, which refers to any component of the network playing its part in a narrative – without which the story is incomplete. Actors in Callon's (2012) case study on electric cars are "the heterogeneous entities that constitute a network", including "electrons, catalysts, accumulators, users, researchers, manufacturers, and ministerial departments defining and enforcing regulations affecting technology." (Bijker, Hughes & Pinch 2012a, 5) Here, I outline a simplified node of human and nonhuman components and their interaction as a network, which I use as a basic unit in my description of sociotechnical environments (see Figure 2).

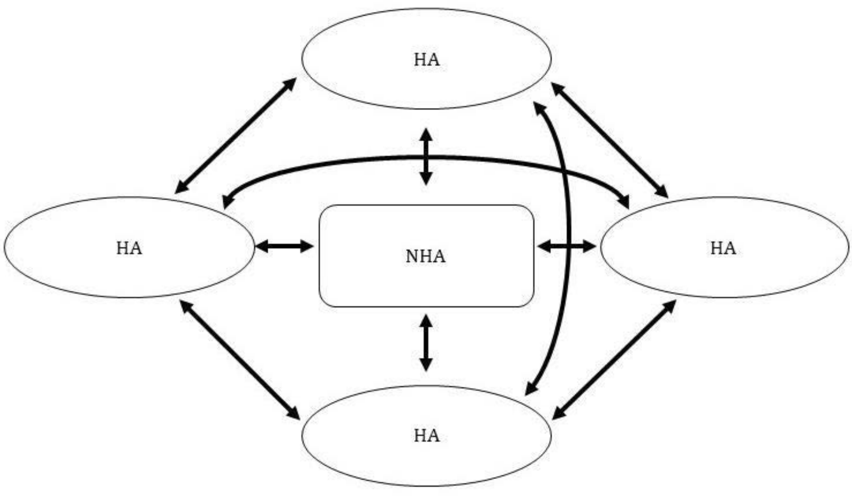

Figure 2. A simplified presentation of one node of a heterogeneous actor network with its human (HA) and nonhuman (NHA) actors or components (Image: Ojanen)

In many cases the network remains invisible, but when a single part of it[48] does not work as it should its structure becomes visible (Leskinen 2000, 184). According to Leskinen's (2000, 186) reading of ANT there is a compromise between its symmetrical pole and the asymmetrical pole of SCOT, hence nonhuman components of the network can "act or exert power". However, their agency is not intentional, it is conditional and dependent on their interaction with the human agent. The outcome of the interaction process is meaningful only when someone interprets it. The following interaction chain

[47] According to Lithuanian-French semiotician Algirdas Julien Greimas (1917–1992).

[48] A part here means HA, NHA or their interaction, i.e. the arrows.

plays a key role in this: 1) human actor (HA) sets the goal for the process when using nonhuman actor (NHA); 2) NHA reacts to HA's maneuvers according to its explicit and implicit features and functionalities; 3) HA reacts to the outcome according to their assessment, in other words HA makes a decision based on whether a) NHA worked as anticipated, b) did not work as hoped but pleasing unexpected effects occurred, or c) did not work at all and the possible outcome was rejected altogether. Thus, interaction could reveal the explicit and implicit features of the technological artifact.

The network is dynamic rather than static, which makes it necessary to consider the perpetual contextualization of the relevant actors and their interaction in the process. This dynamic quality influences the point of departure of my analysis, exemplified in French sociologist Madeline Akrich's (1992) distinction between the designer's *projected user* and the *real user*. The theoretical model initiated by Akrich (ibid.) describing the designer–artifact–user interaction uses the concept of *script*. According to Van Oost (2003, 195):

> *"Designers construct – explicitly or implicitly – images of users 'with specific tastes, competences, motives, aspirations, political prejudices, etc.' and inscribe these representations in the technical content of the new artifact (Akrich 1992, 208). As a result, artifacts contain a script and this script prescribes (in a more or less coercive manner) what users have to do (or not do) to produce the envisioned functioning of the technological artifact."*

Magnusson (2009, 171) also elaborates on the description, stating that technological instruments are "never neutral, [but] they contain scripts that [the users] subscribe to or reject according to [their] ideological constitution." Akrich's distinction between the designer's *projected users* and *real users* can be applied to the different states of technological artifacts for analytical purposes. There is a difference in whether an artifact is analyzed as the designer's initial idea or as a product in the hands of its users. The distinction reflects the two angles from which technological artifacts can be approached.

However, what remains obscure in Akrich's model is that the script does not distinguish between the explicit and implicit features of a technological artifact, which may well explain the confusion between the SCOT and ANT perspectives on the role and location of agency in the network. To elaborate on the analytical frame of technological artifact evaluation, it is possible to analyze the features and functionalities from the designer's (DPoV) and from the user's (UPoV) points of view: both are faced with implicit and explicit features and functionalities that are either deliberately designed or extrinsic to the design process but affect the use (see Figure 3).

From the designer's point of view, the design process primarily concentrates on the intrinsic functionalities of the artifact whereas the extrinsic functionalities are either ignored or remain hidden. From the user's point of view on the other hand, the artifact contains the designer's *de*-scription: the extrinsic functionalities with explicit features amid all the possible ways of using the artifact – even those not envisioned by the designer - as well as the implicit features that are extrinsic to the designer's initial goal. (see also Pinch & Trocco 2002a, 311–313)

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">User's point of view (UPoV)</td></tr>
<tr><td>EXPLICIT
features of an artifact</td><td>IMPLICIT
features of an artifact</td></tr>
<tr><td rowspan="2">Designer's point of view (DPoV)</td><td>INTRINSIC functionalities of the design</td><td>- DPoV: features deliberately designed; the initial purpose of the design
- UPoV: Engagement with the design; rejection leads to two outcomes: 1) the user chooses not to use the artifact; 2) the user rejects the obvious intended use but focuses on modification or abuse and searches for the extrinsic and implicit potential of the artifact</td><td>- UPoV: in the early phase of use, the user does not necessarily know all the deliberately designed functionalities of the artifact and they remain hidden
- DPoV: the functionalities the designer fails to communicate to the real user; i.e. translate from projected user to the real user</td></tr>
<tr><td>EXTRINSIC functionalities of the design</td><td>- DPoV: not related to the initial or immediate design goals of an artifact
- DPoV: easily recognized and can be accepted or rejected; when recognized and accepted they can turn into intrinsic functionality deliberately designed
- UPoV: extrinsic functionalities have potential that can be employed in the use, thereby directing the use</td><td>- UPoV: features disturbing the immersive use situation; the sound of the medium; e.g. the crackling in the sound recording
- DPoV: functionalities and features hidden from the designer; they emerge only in malfunctioning, for example</td></tr>
</table>

Figure 3. The features of a music technological artifact from the perspectives of the designer and the user (Image: Ojanen)

2.2.4 Technology in a musical and historical context

In the context of evaluating musical instruments, O'Modhrain (2011) recognizes four stakeholders in the design process: the audience, the performer or the composer, the designer, and the manufacturer. These stakeholders could be presented as a framework depicting the interaction among the human and nonhuman agents involved in the design and use of the instrument (see Figure 4).

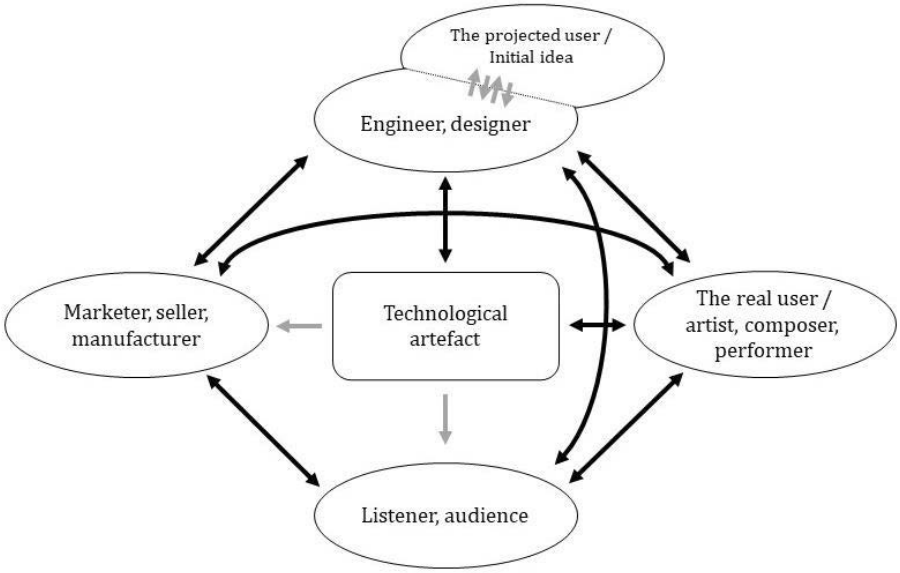

Figure 4. Human actors (HA) considered relevant social groups and nonhuman actors (NHA) considered technological artifacts, and their interaction in the process of instrument design and development, presented in a simplified network; an ideal situation in which all relevant stakeholders have their roles. See also Figures 122 and 123 and the figures in the appendix 1 for descriptions of Kurenniemi's instruments. (image: Ojanen)

On a physical level the music-technological environment includes equipment for producing, processing, and storing sound. Such devices could be described as physical artifacts with features and functionalities. They are discovered, invented, developed, used, and abused by human actors in interaction with each other and with these artifacts. Research and development in the field of music technology go on both in manufacturing companies and in research institutions, as well as in small-scale DIY and audio hardware hacking communities, which are rarely run by one person and usually involve a complex community of actors. However, actors working utterly alone should not be dismissed altogether. On the other hand, the process of producing and composing music, in other words the use of (music) technology, takes place in the studio, which in most cases is a hotbed of social interaction among engineers, artists, composers and producers – and therefore could be considered a technological entity.

As Théberge (2001, 3; in the epigraph of the chapter) notes, in its broadest sense music technology could be considered a comprehensive framework for music-making and consumption in a musical setting. The everyday consumption of music has the power to direct the use of music technology and the production processes such that it is sometimes difficult to detect the boundaries between human, society, culture, and technology. The concept of the *seamless web* aptly describes this situation. For example, to produce or to listen to music is to use and modify technology in one way or another. As Sirppiniemi (2006, 190) points out, "ways of using, making, distributing, and consuming music technology also influence the definition of musical styles and genres".

Musicologist Mark Katz (2010, 2–3), who studied the development of sound recording, came up with the concept of the *phonograph effect*. As he explains, "It's not simply the technology but the relationship between the technology and its users that determines the impact of recording." Moreover, "the influence --- does not flow in one direction only, from technology to user --- [but] users themselves transform recording to meet their needs, desires, and goals, and in doing so continually influence the technology that influences them." Katz's statement could be generalized to include the design of musical instruments as well as of other technological artifacts. Taylor (2001, 31) also elaborated on the determinism question in his practice theory, suggesting that determinism and voluntarism are falsely bi-polarized: "some sociotechnical systems are more deterministic than others though never wholly deterministic, --- some provide for more voluntarism than others though never total voluntarism."

The history of musical equipment provides several examples of technological artifacts – even commercial products – not being used according to the initial purpose. As the development of electronic popular music demonstrates, the unorthodox use of equipment produces sonic expressions and even new musical genres that have a significant aesthetic impact. The cases of the TB-303 bass sequencer manufactured by Roland Corporation and the Auto-Tune tuning-correction software manufactured by Antares Audio Technologies exemplify end-user usage that deviates from the initial purpose of a product. Both examples have had a profound effect on the aesthetics of modern music in various genres of electronic popular music. From this perspective, it cannot be claimed that the development of (music) technology is taking place as a process isolated from society and the cultural context.

The various types of DIY communities, instrument builders, and audio hardware hackers exemplify instrument-building practices that strongly emphasize user-centeredness. DIY and modifying designers propose unorthodox and experimental ideas of what might later grow into a successful means of musical expression. Voorvelt (2000, 67–68) refers to the role of experimentalism in popular music processes when he describes how experimental pop musicians abuse their equipment and instruments to produce new sets of musical sounds and expression, adding that this "helps in keeping pop music alive, diverse and unpredictable." Turning the research focus on these actors resembles the "history from below" approach.

In this sense, my point of departure for this study is at odds with Théberge (1997, 42), who criticizes standard histories that "usually begin with a number of so-called 'pioneers' in the field". He makes apt observations concerning the invention–innovation relationship within the process of designing musical instruments, but his consumer-based theory unnecessarily dismisses the role of "isolated geniuses" and is of little use in artistic and creative genres such as electroacoustic and experimental music. Théberge concentrates on commercial success, whereas in the underground avant-garde art scene electronic musical instruments may be site-specific one-off sound installations. On the other hand, Théberge's statement could be read as a demand for objectivity in writing the history of music technology and, in this respect, it is utterly acceptable.

Technology in a musical context is technology in a creative context, and the bi-polarized dichotomy – technology works or does not work – needs to be revised. Aside from the failing or abused equipment, the influence of technological artifacts may be much more subtle than the TB-303 and Auto-Tune examples. This relates to their implicit features, which are enabled by certain technological qualities. The features emerge as functionalities that are extrinsic to the designer's initial idea. Their existence may even remain hidden until they are recognized and accepted or rejected. In the context of music technology these are exemplified by features of sound quality such as distortion, saturation and the compression of dynamic range by means of a magnetic tape or a vacuum tube, or various random effects due to certain phase behavior of the audio signal. Human decision-making is emphasized in the TB-303 and Auto-Tune examples, meaning that the producers actively try to abuse the equipment. In the latter case the agency is encoded in the technological artifact as implicit features: in other words, its internal quality affects the way the artifact enhances the audio signal.

In the context of musical instruments, for example, active DIY groups are modifying technological artifacts to meet their needs and hopes. Modifications have even been developed into the new commercial products. This shows how relevant social groups can have an essential developmental role throughout the life cycle of a technological artifact. Even though electronic musical instruments gradually established their stabilized form as keyboard instruments during the 1970s, the quest for instruments with new sonic expressions and user interfaces remained vibrant within experimental art scenes. The keyboard instrument became part of the dominant culture, whereas on the margins there was resistance even to the addition of a keyboard to the electronic musical instrument – and the resistance is persistent. Eventually, there may be several parallel stabilized forms of one technological artifact.

The STS approaches attracted criticism in the 1980s when the first publications presented their frameworks. The overarching critique was that even though such approaches concentrated on opening the black box, they found it empty and were unable to explain the sociotechnical change. The ambiguous term agency was difficult to define, for example, and users of technology remained in a minor role. Later, SCOT-based researchers started specifically to emphasize the user's role in the development of technology (see Oudshoorn & Pinch 2003).

2.3 Music: writing music history and definition(s) of music

> *"The concept of a work, seemingly the most stable element of music history, dissolves into a source, an authentic text, a composer's intention, and an historian's notion as to the musical significance of the acoustical substrate sketched out by the text or realized according to the guidelines laid down with it."*
>
> *Music philosopher and historian Carl Dahlhaus (1983, 35)*

The general historiographical concepts and argumentation I have reviewed in the previous chapters are applicable to the history of music. However, a few specific factors distinguish music from other historical subjects. One key difference is the dual role of a musical work – as well as serving as documentary evidence of the past, it is an aesthetic object of the present. According to Dahlhaus (1983[49], 20–23; see also Huttunen 1993, 23), the documentary value of a musical work in the writing of music history emerged only after the Second World War. Not only do technology-driven musical works and sound recordings have such documentary value, they also provide documentary evidence of the state and quality of the technology used in their realization.

Scholars considering the documentary value of a musical work debate about the continuity and discontinuity of historical evidence. Regardless of the number of musical works that are studied, they provide only fragmented evidence. This calls into question the possibility of formulating an adequate explanation of the past solely by studying musical works. On the one hand it is suggested that a study focusing on works of art as autonomous objects cannot produce a consistent description of the past, whereas on the other hand it is suggested that researchers concentrating on other than musical aspects do not write the history of music. (Dahlhaus 1983, 19–20; Sarjala 2002; Shreffler 2003, 514–15) The key debate on this issue has focused on the acceptable content of musicology and the directed writing of music history. From this perspective, music history writing, music philosophy and aesthetics are tightly intertwined.

2.3.1 Writing music history

Philosopher Lydia Goehr (1992) aptly points out the similarities of three works on music historiography published in the late-1980s.[50] According to Goehr, all three writers capture

[49] It is notable that Dahlhaus's dual definition derives from Johann Gustav Droysen's ideas presented in *Historik* (Droysen 1953[1857], Dahlhaus 1983, 3–4).

[50] Dahlhaus, Carl (1989) *Nineteenth–Century Music*; Meyer, Leonard B. (1989) *Style and music: Theory, history and Ideology*; Treitler, Leo (1989) *Music and the historical imagination*.

> *"a common and very basic concern: to reconcile the desire to treat musical works as purely musical entities with value and significance of their own – with the desire to account for the fact that such works are conditioned by the historical, social, and psychological contexts in which they are produced."*

This juxtaposition has "plagued musical scholarship for at least two hundred years", and the problem emerges when writers are "faithful to one side at the expense of the other" (Goehr 1992, passim). Thus, the writing of music history has become intertwined with the definition of a musical work in a way that warrants more detailed investigation into the development of the discipline.

As Goehr notes, the debate over musical and non-musical content persists. Musicology has been characterized by the Adlerian[51] *systematic* and *historical* division since the late-19th century (see also Huttunen 1993). Despite later criticism, the discipline was essentially founded upon this distinction,[52] which reflects attempts to define its acceptable content. Sarjala (2002, 26–27), expressing another point of view, suggests that the target of the research specifically defines how far the researcher can diverge from music and still call him- or herself a musicologist. In other words, the research target dictates the contents of the musicological profession. Sarjala (ibid., passim.) criticizes Finnish musicologists for focusing solely on composers and musical works, and not on music in its cultural context. In his view, writing on music history that is based on the study of musical works as autonomous entities is too narrow and implicitly political.

Throughout the history of musicology, attempts to reconcile the musical and the extra-musical have concentrated on adjusting the discipline by redefining its focus. This has not halted the debate, however. On the contrary, questions that emerged in the early-1980s (see Tomlinson 1984) are still relevant. Quite recently in the 2010s, for example, Mantere & Kurkela (2015, 5) claimed that there was no consensus as to whether future research should focus on sound or on its cultural, social, and historical context. Similar concerns have been expressed by the international community of popular music researchers initiated by Philip Tagg (see e.g. Tagg 2015). Sivuoja-Kauppala et al. (2013, 3–4), summing up the situation, state that composers and works are not banned as research subjects, but just as in general historiography with its multitude of methods and targets, non- or extra-musical issues are also acknowledged as a relevant ingredient of music research and music history. Again, the discussion turns toward *thick description*.

The debate on the content of musicology has not been restricted to the discipline, having spread to music studies and other branches of research in

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[51] According to Austrian musicologist Guido Adler (1855–1941).
[52] Juxtapositions as aesthetic and historical (Dahlhaus 1983, 19–33; Goehr 1992), analytic and historical (Goehr 1992; Huttunen 1993), and historical and non-historical (Huttunen 1993, 4) were used later.

art and culture. According to Sarjala (2002, 21, 29), most music history is written by musicologists, not historians, many of whom lack expertise in methods of history writing. However, as Burke (1991b, 2–6) pointed out, the reign of exclusively professional historiographers collapsed during the second half of the 20th century, since when history writing has been considered a legitimate activity in disciplines other than history, and not limited exclusively to trained historians. The contention between musicology and the other disciplines arose from the notion that music is a specific entity the study of which requires a thorough musicological education. As Huttunen (1993, 7–8) states, for example: "musicologists would not accept a music historiographical study, if its material had not been defined with music theoretical concepts." From this standpoint, the writing of music history requires musicological expertise rather than a degree in history studies.

The role of the musical work as the primary focus in music history is also linked to canonization, which is a process that emerges when the researcher exemplifies an argument with a set of selected works considered worth studying. It has even been stated that no "trivial music" can be used as an example (see Dahlhaus 1983, 19–20; Shreffler 2003, 515). According to Huttunen (1995, 22):

> *"- - - there's no reason to restrict canon to musical works. If we think of the historian's work as a whole, we should extend the concept of 'canon' to comprise all other factors of music history, too. A certain class of historical persons, events, trends and other historical facts (understood in the very wide sense of the word) has become canonic. Instead of 'reportorial canon' we should perhaps rather speak of the 'canon of facts'".*

Thus "the canon functions as a basic tool in defining the scope of this discipline" (Kurkela & Väkevä 2009, vii).

The principles of canon formation are questioned, especially by critical (ethno)musicologists and postmodern writers who wonder on what grounds certain works and composers are selected, and others are excluded (Mantere & Kurkela 2015, 1). Concentrating solely on selected works overshadows others, and implicitly puts them in a minor position – or even destroys them (see Adorno 2006, 34). Selecting examples for historical description means making an implicit value judgement.

Problems associated with canonization have inspired writers of music history to search for solutions. Terms such as probing canons, de-canonization, and de-construction have recently emerged in the literature (see Kurkela & Väkevä 2009; Mantere & Kurkela 2015). Turning the focus away from canonized composers and selecting a work from outside the canon resembles the *history from below* approach in two ways: it is accepted that everything has a history, and the perspective shifts to that of ordinary people or those in the margins (Burke 1991b 2–6; see also Chapter 2.1). Focusing on the marginal resembles the shift in research to failed designs in Science and Technology Studies (see also Chapter 2.2).

However, as Gloag (2015, 231) observes, once critical postmodernism has built its own canon its "story is a singular one." Kurkela & Väkevä (2009, viii), in turn, describe how "[d]ifferent musics have already formed their own canons." Choosing to examine a minor subject is to draw more people and works into the canon rather than to de-construct it. Focusing on the new subject inevitably overshadows other subjects and, in this respect, canons cannot be avoided (ibid.), but researchers should be conscious of the process, and clearly explain why they have selected a certain set of works to exemplify a certain phenomenon. This clearly resembles the demands of Burke (1991a, 239) and Megill (2007, 1–3) for researchers to make themselves, their attitudes and their intentions visible to the reader (see Chapter 2.1 on history writing). Moreover, instead of referring to *de-canonization*, writers should rather discuss perpetual *re-canonization* as an unavoidable feature of (music) history writing. With regard to the subject of this study, it is already clear that research centered on Kurenniemi shadows other actors in the field and gives a one-sided description of electroacoustic music in Finland.

Questions concerning the research focus and how to define which features are musical and extra- or non-musical, which the discussion on the writing of music history triggered, are of significance to anyone analyzing and writing the history of electroacoustic music. Descriptive cultural and historical writing is essential, but it only covers one side of music: a clear definition is required to set the focus and to thicken the descriptions. My target within this study is to reach Goehrean integration, in other words to find a balance between analyzing works – here both musical work and musical instruments – as "purely musical entities with value and significance of their own", and to consider "the fact that such works are conditioned by the historical, social, and psychological contexts in which they are produced" (Goehr 1992, 182).

Whereas Goehr approaches the question from the producer's point of view, Camilleri & Smalley (1998, 7) diversify the contextualization of electroacoustic music to the receiver, redirecting the analytical goal to the reconciliation of the internal world of work with the outside world. As Goehr (1992, 194–195) points out, the dispute continues if one side is considered essential and the other contingent. Definitions of music and a musical work are needed to delineate the target of research on electroacoustic music, and these are to be found in concepts developed within music philosophy and aesthetics.

2.3.2 The concepts of music and a musical work

Whereas the historiographical questions posed in the previous sections are mainly epistemological, the quest for a definition of music diversifies the discussion into ontological themes. Roughly defined, concepts and theories developed within philosophical approaches, such as ontology and semiotics or semiology (Hatten 1992[53], 88; see also Dunsby 1983, 27), cover the essence of the research target, whereas aesthetics concentrates on questions of perception – especially in the domain of art. However, as several researchers note, the line separating philosophy, ontology, semiotics, and aesthetics is somewhat ambiguous. Aesthetics, for example, also covers broad questions concerning the essence and existence of art.[54] (Padilla & Torvinen 2005, 10–11; Tarasti 2012, 3–10)

Aesthetics has traditionally been concerned with the judgement of perception, especially in the beauty and value of artworks. However, topics of interest diversified during the 20th century to cover perceptions of the unbeautiful and the ugly. The focus of aesthetic scrutiny has broadened from experimental and electronic music to formerly taboo phenomena such as noise and silence. Twentieth-century experimentalism in particular challenged scholars to debate categorizations such as art vs. non-art, and music vs. non-music. A further focus in addition to all this is on studying the artist's intentions and how they are received by the recipient of the artwork or performance. (Hamilton 2007; Demers 2010, 164; Tarasti 2012, 4)

According to Demers (2010, 5), aesthetics theory, unlike ethnography and descriptive history writing, provides interpretations of phenomena, as: "the aesthetic interpretive subject - - - reflects critically, albeit imperfectly" and does not "claim a truth content" as easily as an ethnographer. Demers does not refer to Geertz's *thick description* or to Megill's *unresolving tension* as a historiographical paradigm, but the resemblance to these concepts is clear. His comment also resonates with the views of Tomlinson (1984) and Emmerson & Landy (2016, 22), who state that analyses based on the mere description of musical works as objects detached from their production or reception produce thin descriptions. Again, contextualization is needed to thicken the descriptions.

As I report in the previous chapter, one of the main contentions in music research is based on seemingly exclusive categories of music as *an autonomous object* and music as *an object in relation to its production* or *its perception*: musical vs. extra-musical, in short. The line between the two is arbitrary. To facilitate the definition of what the work in electroacoustic music is, I describe a few attempts that have been made to define *music* and *musical work* and how they relate to the discussion about music as an autonomous object or absolute music. Researchers may choose to approach music from either of these perspectives, although both complement each other.

[53] According to Hatten, semiology is used by French writers whereas English writers use semiotics, although the choice of term is not merely a question of language "but there is a real difference between the more structuralist perspective of Saussure's semiology and a Peircean semiotic that provides a hermeneutic component as well."
[54] Ala-Könni et al. (1977, 354–355).

The above-mentioned categorization forms a basis for a threefold perspective that is applicable not only to writing music history but also to music analysis. This division into three parts has its roots in the concepts of *poiesis* and *esthesic*, which derive from the Ancient Greek words for “to create” or “to make” (-poietic), and “to sense” or “to perceive” (-esthesic). Jean Molino (1990) uses these concepts in his semiology-based tripartition model (see Figure 5), which his student Jean-Jacques Nattiez (1975; 1990) developed further. Molino borrowed the word esthesic from Paul Valery, and poietic from Étienne Gilson (Molino 1990, 129–130), the former being Valery’s neologism of the Greek word for aesthetics (Nattiez 1990, 12). The model is based on semiotics and linguistics, and it describes the complex processes of creating (producing) and interpreting (perceiving) the meaning of a (musical) work.

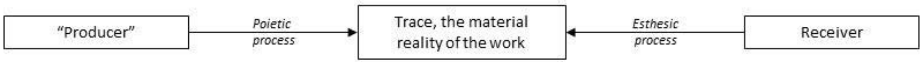

Figure 5. Nattiez’s tripartition model (1975, 52; 1990, 17)

According to Nattiez (1990, 16–17), the tripartition model is not based on the traditional model of communication theory implying that the message is carried from sender to receiver in a straightforward process. On the contrary, the assumption is that the meaning is constructed in two different processes, first by the composer in the *poietic process* and later by the receiver of the work in the *esthesic process*. Thus, the meaning is not necessarily the same to both parties, and any similarity between the composer’s intentions and the receiver’s interpretation is serendipitous.

Should the receiver assign the same – or even a somewhat similar – meaning to the work, or interpret it according to the composer’s intentions, it is because composer and receiver share similar cultural and historical backgrounds, personal attitudes or traits, and experiences, for example. Guidelines dictated by the musical genre also play a significant role in both poietic and esthesic processes. Music – as a subject of research – can be approached from either of these perspectives (see also Chapter 3.3 for a description of the methodology used in the study).

Tripartition also accounts for the *material reality of the work*, in other words the physical traces resulting from the poietic process including the “work’s live production, its score, its printed text, etc.” (Nattiez 1990, 15). The material reality does not include or consist of one stable meaning, message, or signification per se, neither does it convey the composer’s intention (ibid., 15). It is merely a vehicle that triggers the esthesic process – a process during which the receiver creates his or her interpretation of the work or assigns a meaning to it. The material reality of a work has been considered *an objective entity* and described as *the neutral level*, which has rightfully been criticized. Critics have challenged the description of music on this level for two main reasons.

First, approaching a work on a neutral level has been considered epistemologically impossible (e.g. Hatten 1992; Samuels 2004). The work as a neutral object disappears when it is examined, or as Demers (2010, 11) states: "[a]n author who claims complete objectivity and value-free neutrality is - - - being disingenuous, since every observer has a point of view." The criticism resonates with general historiographical tenets, such as put forward by historian Edward Hallett Carr (in Tomlinson 1984, 354):

> *"[t]he belief in hard core historical facts existing objectively and independently of the interpretation of the historian is a preposterous fallacy, but one which it is very hard to eradicate."*

Nattiez (1989; 1990) did not mean that an objective neutral level could exist, however. Nor did he demand "scientific neutrality on the part of the author of analyses" (Nattiez 1989, 36): his first revision (Nattiez 1975) was misread by scholars. He aimed to analyze *the immanent sonorous configurations of the work* (Nattiez 1990, 61), in other words its *material reality*. My aim in this study is to dodge ontological discussion, although I acknowledge that I take an ontological stand in basing it on the assumption that a musical work as a material reality with measurable and observable features exists. This seems to be a perpetual bone of contention within the research community.

Second, it has been stated that analysis conducted on only the neutral level produces a thin description (Tomlinson 1984; Emmerson & Landy 2016). On the material level the work disregards the details related to both the poietic process of the composer and the esthesic process of the receiver – as well as to the performance of the work. Nattiez considered the neutral level simply a point of departure for analysis – and the analysis should be complemented with examination of the poietic and esthesic processes. As Emmerson & Landy (2016, 22) point out, technology-oriented musical works such as glitch techno tracks lose crucial parts of their meaning if they are approached only from the point of view of the listener. Here, they use the concept *poietic leakage* to emphasize the need for contextualization. Thus, locating the meaning of music cannot be based only on a description of the material reality of the work.

Especially in the context of electroacoustic music – or any music on media that can dislocate it from its original context – the analysis remains thin when examined only on the level of the work's material reality. Even in the case of recorded music, in which it is seemingly static (constant or unaltered), approaching a musical work only as the material trace of the poietic process is ambiguous.[55] Detached from the original context, music or sonic events start to live a life of their own without necessarily any reference to their origin. According to Talbot (2000, 185), "recorded sound has the power

[55] For a more detailed discussion about the influence of the digitization process and the role of the technical engineer in music analysis see e.g. Ojanen (2015).

to turn non-works into real works. Once it has been recorded, improvised music - - - acquires a fixed, infinitely repeatable essence that allows it to be treated as a quasi-work." On the other hand, one could ask whether the musical meaning is located in the work or only in a fleeting improvised performance. According to Lebanese sound artist Tarek Atoui[56] and the aesthetics of the STEIM Studio, their art loses its (original) meaning when documented as a sound or video recording.

It is worth pointing out here that concepts such as *absolute music* and *music as an autonomous object* are not interchangeable with the neutral level as described by Nattiez. The concept of *absolute music* outlined by 19th-century German composer Richard Wagner denotes instrumental music without any reference outside of itself, and contrasts with *program music* (Dahlhaus 1989; Ashby 2010). As described by Demers (2010, 163), absolute music refers to "western art music that supposedly transcends language and forsakes explicit associations with outside world. Absolute music is instrumental music that lacks a program or other extramusical narrative or explanation."

The ability of a musical work – a *work* understood here as a material trace of the poietic process – to refer outside itself is not dependent on the composer's intention or the perceiver's ability or willingness to form such references. The *material reality of a musical work* and *its meaning* can be likened to the *mass of a physical object* and *its weight*, respectively. The object has its mass regardless of its outside circumstances. Only when it is placed under gravity does it gain weight, which is defined by both the internal properties of the object and its surrounding circumstances. Thus, the construction of the meaning is dependent on both the immanent sonic configuration of the work and the context in which this configuration is perceived. Roman Ingarden, having noticed this flexibility in the signification of the work's musical meaning, explains that each epoch interprets musical works in its own way and defines what is correct and what is authentic at the time, according to either the public or the performer (in Nattiez 1990, 74).

It is also worth noting here that Goehr (1992, 186) warns against conflating the concepts of music and a musical work. She refers to her key argument in *The Imaginary Museum of Musical Works* (Goehr 2007) that the concept of *a musical work* emerged around the year 1800: prior to that date, composers were not able to think of or define their compositions as works. She further argues (Goehr 2007) that, when considered a work, music has regulative power, which dictates how the works are performed and how the music is used. Even though she concentrates on classical music, in which the work concept even drives concert practices, her argument has explanatory power over the processes of electroacoustic music production and performance. As I show in this study, users of Kurenniemi's instruments differ in their attitudes

[56] Personal communication with Atoui in 2012.

towards the definitions of music and a musical work. As an extreme example, it could be said that Kurenniemi produced music, but he did not compose musical works. Moreover, his electronic musical instrument of the future was supposed to produce digital on-demand music at the flick of switch whenever needed. He[57] predicted that, in the age of digital music production, music would lose its identity and, if nothing else, it would be cheap – I read this to mean that there would be no copyright. From this perspective, it is not fruitful to classify Kurenniemi's future digital music as works that have regulative power. Endless music flow can be acquired on demand.

I use concepts from aesthetics as tools for unveiling the subject of this study rather than for defining what is valued as good, beautiful, or ugly in electronic music. The historiographical contention over the musical and the extra/non-musical challenges music analysis. To focus the analysis within this work, one primary task is to contemplate questions such as how to define electroacoustic and technology-driven music; what kind of information can be gained from it; and from what perspectives it can be approached. According to Demers (2010, 158–159), the aesthetic theory of electroacoustic music needs particularly to consider "how nonmusical sound differs from traditionally musical sound".

Electroacoustic music together with the design and use of electronic musical instruments provide an excellent testbed for seeking answers to these questions. As a theoretical set of concepts, Nattiez's tripartition is an effective point of departure for setting the focus of music analysis. Enhancing understanding of electroacoustic music in its context requires investigation into instrument-building practices on the one hand, and performance and perception practices on the other. I discuss this in more detail in the chapter on methodology (Chapter 3). Before that, to put this study in context, I outline various definitions of electroacoustic music.

2.3.3 Definitions of electroacoustic music

The concept of *electroacoustic music* has been evolving since the 1950s (Emmerson & Smalley 2001; Weale 2005). Its definition and content vary not only across disciplines but also across geographical locations and professions. In the context of this study, I use *electroacoustic music* as an umbrella term referring to the technology-emphasized musical genres and styles that developed mainly in the West starting in the mid-1940s. Like many other genres, electroacoustic music breaks down into several sub-genres. As Emmerson & Landy (2016, 8) point out, the EARS website lists 81 sub-genres of electroacoustic music. Here, I simplify matters and use the term electroacoustic music to "bind together facts that other" advocates "keep separate" (Nattiez 1990, 55).

[57] Kurenniemi (1967) in an interview with Oura.

Within this study, electroacoustic music refers to musical styles and genres such as *electronic* (both general *electronic music* and the German *elektronische Musik*), *concrete* (the French musique concrète), *acousmatic*, and *tape music*, and to some extent *live electronic* and *computer music*. Genres that have emerged with an emphasis on popular culture such as *electronica*, *intelligent* or *electronic dance music* (IDM or EDM), *techno*, *microsound*, *glitch*, and *ambient* could also be categorized under electroacoustic music, but they fall beyond the time frame of this study. The division between *high* and *low*, in other words between *classical art music* and *popular-culture-oriented music*, on the other hand, is of special relevance to the discussion on electroacoustic music.

In addition, genres such as *sonic*, *sound*, and *sounding art*, as well as *sound installation* and *Klangkunst* are very closely linked to electroacoustic music and are sometimes categorized as part of it. Many works and artists discussed in this study could be categorized under contemporary sonic or sound art but, given that the terms *sound* and *sonic art* have been widely used only since the 1980s, describing artists of the 1960s in such terms would be anachronistic. Of course, there are always exceptions: Gordon Mumma, Robert Ashley, David Behrman, and Alvin Lucier, for example, used the name Sonic Arts Group – and later Sonic Arts Union – as early as in the 1960s in the United States (Mumma 2015, 298). Nevertheless, most contemporary sources that served as research material for this study use the term electroacoustic music, whereas sound art and its variants are rarely mentioned. Moreover, none of the above-mentioned popular electronic music genres – at least by name – appeared within the time frame of this study. Thus, the question of terminology is significant when considering issues related to emic and etic approaches to the research project.

In the context of this study, the term *acousmatic music* requires special attention. Besides being a musical genre in itself nowadays, it is a term with overarching significance within electroacoustic music. As a musical genre it is a special type of *electroacoustic tape music*, the origin of which is in French concrete music (*musique concrète*). *Acousmatic music* also refers to listening situations in which the sound is detached from its source, meaning that the listener cannot see the cause of the sound. The term refers to Pythagoras, who spoke behind a curtain to enable his pupils to concentrate on the contents of his lectures rather than on him (Schaeffer 2017, 64; see also Kane 2014, 45–72 for a critical review of the myth of the Pythagorean veil). Electroacoustic music is typically *standalone tape music*, which is produced in the studio environment directly on tape and reproduced through loudspeakers from the sound recording in the concert setting: in other words, members of the audience perceive only the sound and do not see the poietic process or the performance. Paradoxically, this was the key feature of standalone electroacoustic music in the 1970s, for which it was criticized.

Electroacoustic music is also closely related to experimental music, although the two are not mutually exclusive. Experimentalism could be considered a built-in feature of electroacoustic music due to its origin. At the dawn of electroacoustic music there were no ready-made instruments dedicated to music production, hence the development of the genre rested on an interest in testing how general-purpose equipment could be used in music or sound production – and the conscious envisioning of musical instruments of the future.

According to Demers (2010, 7), *experimental* is a time-bound, dynamic and evolving feature of artistic activity and the direct opposite of *conventional*. The notion of *experimental* and *conventional* dynamics in the context of electroacoustic music enriches and fulfills these reflections, as Demers (ibid.) concludes: "- - - something experimental in 1985 could have inspired what was conventional by 1990." Poschardt (in Monroe 2003) made similar remarks, referring to pop culture as an "instrument with which counterculture is turned into the dominant culture"; and according to Voorvelt (2000, 68), "we often find that experimental techniques, albeit slowly, leak into the mainstream, so that experimental musicians are often more influential than they might seem." Ballantine (1977, 241), in turn, states:

> *"the scientific frame of mind of 'what can we discover? is thus one of the central irreducible feature of experimental music." --- "Such a frame of mind is totally future-oriented: its sole intention is to produce the future. By comparison, Western traditional music tells us what is, or has been, known or hoped or felt; its performances reproduce the past."*

I see *electronic media* as a tool, and *experimentalism* as a tenet. A composer or an artist is free to use any tool that he or she finds appropriate while acquiring an attitude, which is either *conventional*, *traditional* or *experimental*. Experimentalism was a core feature of electroacoustic music in its early days. There was no tradition within the genre, and in particular the instruments were new – even intended to break free from traditional practices of both design and performance. Later, when composers and artists had adjusted to the medium, its neutral, value-free nature disappeared and similar attitudes that defined *high-art* and *popular* started to describe the works realized by electronic means. This comes out clearly in the material used for this study.

The background of electroacoustic music can be traced to various developments in music, culture, and technology during the 19th and 20th centuries. The historical overview of electroacoustic music and its relevant preconditions I present in Chapter 4 traces the preconditions of global developments, of Kurenniemi's instrument design, and of electroacoustic music in Finland in the 1960s and 1970s.

3 METHODOLOGY

In this chapter I present the methodological toolbox I used when writing my history of music technology, the emphasis being on the source-material-driven qualitative approach. Including quantitative tools would have been beneficial.[58] General qualitative methods underlie all three themes of the study – history, technology, and music – whereas technology and music studies in particular have their specific applications of the general methodological tenets. First, I describe the similarities between the chosen methods. Next, I elaborate on the specific tools employed in the research on electronic musical instruments, and then in analyses of electroacoustic music, both of which are within the scope of this study. It is worth noting that some of the theoretical (see Chapter 2) and methodological concepts overlap. One concept I consider important from the methodological perspective is *microhistorical observation scaling*, as described by Levi (1991) in particular.

3.1 Writing a history of music technology as a qualitative research project

The subject of this study – in the broadest sense – covers practices in the design of electronic musical instruments and the use of these instruments in electroacoustic music compositions and performances in Finland during the 1960s and 1970s. On the more concrete level of research material, the study is based on three types of primary objects: 1) historical events,[59] 2) technological artifacts,[60] and 3) works of art.[61] I examine these objects to enhance understanding of the subject.

Primary objects have two kinds of roles, which should be considered when they are interpreted. They may be static and time-bound objects related to a certain event in the past, or fluid objects that assume different meanings at different times and in different contexts. Primarily, this division is related to

[58] However, had I employed statistical methods I would have outlined the overall research design – especially the data collection – differently from the very beginning of the project. For future purposes and to broaden the project to include statistical, machine-actionable, and research data, I pilot-tested research-driven metadata production. See Ojanen, Mikko. 2019. Preliminary metadata for the UHMRL digital tape archive pilot (Version 20191223_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3591336

[59] Such as concerts, happenings, performances, exhibitions, conferences, seminars, and meetings.

[60] Such as musical instruments and technological devices.

[61] Such as music and musical works, poetry, sculptures, sound installations, and dance works.

the notion that music – or more precisely, a musical work – is both an aesthetic object of the present and documentary evidence through which the past can be approached (Dahlhaus 1983, 4; see also Goehr 1992, 194; Huttunen 1993, 19). I argue that technological artifacts have a similar dual role. On the analytical level, technological artifacts and musical works could be considered within the same framework: for both there is the creator, material evidence of the creation process, and the receiver or user.

Within this study, I view history writing as an interpretative and hermeneutic project (see Carr 1986, 24; see also Chapter 2). Documentary evidence of the past is turned into hermeneutic units[62] through selection and annotation. Premises that are too narrow may direct the analysis in a predetermined direction such that the results reflect the researcher's hypotheses rather than the subject of the study. The researcher should pay attention to the details affecting the interpretation. In practice, therefore, history writing is intensive interplay among the research material, the methods, and the target of the project. The input of the researcher has a significant role in terms of his or her own background and motives – whether conscious or suppressed.

I start with my research task and initial questions, which I fine-tune during the process. From this point of departure, I proceed bottom-up and top-down, in turn. In other words, although the project is source-material-driven, I anchor the study in previous research traditions by detecting existing concepts and models that give it explanatory power. In many cases, these concepts and models help me to target my analytical view or to describe details in the material, although sometimes previous models or prior analyses turn out to be deficient or biased and need to be revised. Thus, my research setting emphasizes the inductive research approach, with concepts and theories lurking in the background (see also Katz 2012, 8–9).

The mechanism of selecting pertinent features from the research material resembles qualitative research settings such as content analysis. I borrow my overarching methodological concept, *pertinences*, from the context of electroacoustic music analysis, and employ it as a general qualitative tool. The concept was initially outlined by Delalande and then revised by Camilleri & Smalley (1998, 5). According to Delalande (1998, 19; Camilleri & Smalley 1998, 5) *pertinences* are "salient sonic features", which are "considered relevant", in line with the question, and "lead to analysis". In the context of electroacoustic music, the chosen *listening strategy* directs the selection of pertinences, which also resembles the analytical perspective in the content analysis. When one is surrounded by a plethora of research material it is important to acknowledge that not everything can be studied. Here, the idea of pertinences helps to frame the project.

The first concrete methodological steps taken in this study were the *collection* and *selection of the material*. In this process, categorizing and choos-

[62] I borrow the concept from the qualitative research software Atlas.ti.

ing the pertinent features guided the response to the research questions. Furthermore, it was necessary to analyze and interpret both the documents and the gaps in them. I clarified the relationship between the research target and the source material by mapping them with their role and position in the research process (see Table 1).

Table 1. The relationship between the research target, the source material and their role and position in the research process

Levels of examination	**Status of source and data**	**Description of the object of examination**
The sixth level	Interpretation	The synthesis of the research questions, methods and analysis
The fifth level	Analysis	Based on the fourth-level data
The fourth level	Research data	Categorized, systemized, selected primary and secondary sources: the pertinences
The third level	Secondary source material	Retrospective interviews, imaging methods (= annotated sonograms), annotated contemporary documentary evidence, observations from the contemporary documentary evidence, previous research literature
The second level	Primary source material	Contemporary documentary evidence: photos, record sleeves, letters, applications, magazine and newspaper texts, audio and video documents, contemporary interviews concerning the events, technological artifacts and musical works
The ground level	The target of the study	The past

As I explain in the theoretical chapters, the target of the study on the ground level – that is, the past – cannot be accessed directly and has to be approached through the primary source material. The secondary source material, on the other hand, cannot be trusted without verification via *source criticism* and *cross-referencing*: both are major methodological tools at every turn – even with regard to the primary source material. The three upper levels concern the material and data produced within the study. The farther I move from the ground level the more relevant is my subjective interpretation. As an underlying methodological tenet, I elaborate on the role of my subjective point of view via the concepts *accepting unresolving tension* and *avoiding hindsight*.

The importance of source criticism and cross-referencing is highlighted especially in handling the interview material – both the contemporary historical interviews and those conducted more recently. As Megill (2007, 49–50) notes, oral history, which is based on memory, does not qualify as a primary source. Memory-based material that serves as evidence of the past in history writing should therefore be considered a secondary source. Megill (2007, 25) distinguishes between traces and sources thus: “sources are always already interpretation of events whereas traces are not. Traces are insulated from people’s (un)conscious wishes to remember. Memory lacks this kind of objectivity.”

For the most part I conducted the interviews I use in this study in collaboration with Jari Suominen, Kai Lassfolk, and Marko Home. As unstructured in-person thematic interviews they are thus typical research material in the field of oral and communicative history. Along with our open-ended questions, we used original documentary evidence as memory-evocation aids. During our interviews in the 2000s I was able to use several interviews conducted by composer Jukka Ruohomäki in the 1990s for his research project on the history of electroacoustic music in Finland. The focus of this study is on the 1960s and 1970s, therefore I consider the interviews to be secondary sources: in another research setting such as if composers and artists were asked how they currently felt about their past, the present interview material could serve as a primary source.

I crosschecked the interview material with other sources such as contemporary newspaper articles, journals, diaries, and daily planners, among other documents, thereby ensuring material *triangulation*. Discussion based on open-ended questions should be categorized and re-arranged according to its pertinence to the research task and questions. From this perspective, the interview method serves not only to discover or verify facts, but also to sketch the historical interpretation.

Memory-based problems arose not only in the interviews but also in the contemporary historical material. This is exemplified in composer Jarmo Sermilä's interview with composer Osmo Lindeman in 1975, in which Lindeman recalls his experience of electroacoustic music starting in 1968. Even though the focus was on the previous seven years, memory-based problems arose in the material.

In my view, both basic research on the historical details and overarching structural analysis of the circumstances are essential. Even though several researchers have already written about electroacoustic music in Finland, previously unknown events, musical works and even technological artifacts and actors are constantly being discovered. It is typical of history projects in particular that the data collection does not necessarily end even when the project ends as new material enhancing the analysis and the interpretation is discovered from one project to another. Thus, it is becoming increasingly important to make newly discovered material openly available. To ensure transparency of the research process and methodology, and to facilitate future projects, I have made all the material and data openly available within the constraints of the ethical conduct of research: in other words, I respect privacy and copyright issues, respectively, when managing the documentary and interview material, and the works of art.

3.2 The analysis of electronic musical instruments

A critical point of departure in research on electronic musical instruments is to avoid anachronism and hindsight. First, it should be borne in mind that if one studies the design of historical electronic musical instrument from the perspective of the present, current knowledge about the various features of modern digital musical instruments (DMIs), for example, is far more detailed than was thinkable among instrument builders of the 1960s and 1970s. Technology not only changes but also improves, and more knowledge is encoded in technological artifacts today than 50 years ago. Second, modern methods and concepts applied in the evaluation of musical instruments identify features in interfaces and control processes that could not have been imagined when the original instruments were designed. Third, it may be difficult to describe a historical instrument based on its current condition. If these challenges are kept in mind, historical instruments can be considered in light of the features in modern instruments and knowledge of current design processes.

One of the major changes in the development of musical instruments within the time frame of this study coincided with the appearance of so-called digital musical instruments (DMIs). Magnusson (2009, 172) distinguishes three types of musical instrument: acoustic, electronic, and digital. Acoustic and electronic instruments are designed bottom-up whereas digital musical instruments are designed top-down (ibid.). He describes acoustic instruments as embodied, extending the performer's body, whereas digital instruments are hermeneutic, cognitive extensions of the performer's mind rather than the body. Moreover, designers of digital instruments must have a thorough knowledge of theories of musical acoustics and programming languages. (ibid.) When he writes about digital instruments, Magnusson refers to designs that distinguish software from hardware, in other words the programming language and the code from the physical machinery. Within the scope of this study, Kurenniemi designed digital instruments with electronics hardware, the software being encoded in the physical electronics. Beyond this technology-based categorization, so-called electroacoustic and case-specific instruments such as sound installations should be recognized as a separate category.

Within the organological categorization of instruments, the design process can be evaluated from different angles. First, as with any technological artifact, the conception of an instrument on the initial level of design may differ significantly from what was eventually realized, as may the way it came to be used (see Akrich 1992; see also Chapter 2.2.3). Second, recognizing the goal of the design directs the analysis of the process. There are differences in 1) whether instrument building is seen as DIY practice or as a project aiming at a commercial product; 2) whether the goal is to build a case-specific or a general-purpose instrument; and 3) whether the instrument is meant to be used in live performance or in the studio as a sound generator, for example. These categories are not exclusive, and the instrument may even move from one category to another during its life cycle. Third, instruments can be assessed from the various stakeholders' points of view. According to O'Modhrain's framework for the evaluation of digital musical instruments, stakeholders in the design process include, for example, the audience, the performer or composer, the designer, and the manufacturer (see O'Modhrain 2011, 38; Magnusson 2009, 171; see also Chapter 2.2.4). I employ these categorizations as methodological tools in this study.

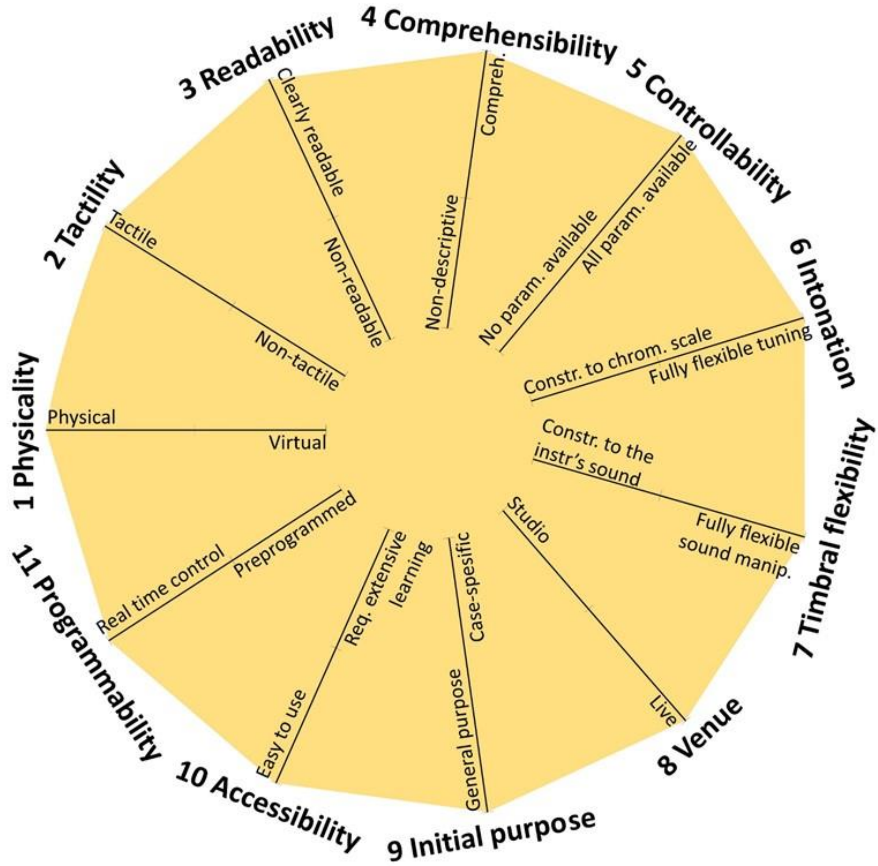

Figure 6. A dimension-space visualization template for charting the key features of the user interfaces and functionalities of Kurenniemi's electronic musical instruments (Image: Ojanen)

Within the modern DMI context, several researchers have developed assessment methods and visualization tools for systematizing their designs (see Birnbaum et al. 2005; Hattwick & Wanderley 2012). Their main goal is to develop their current projects further, whereas the tools have also been used in DMI analysis (see Magnusson 2010). One flexible tool for charting the chosen features, visualizing the data and facilitating comparison across various designs is the dimension space plot, which was initially developed in the Human-Computer-Interaction research stream at the turn of the millennium (see Wanderley 2001, 2002). The chosen features of an artifact can be mapped onto their own axes and visualized as a dimension space. Here, I employ dimension spaces to chart, visualize and compare the key features (*pertinences*) of the user interfaces and functionalities of Kurenniemi's instruments (see Figure 6).

As Birnbaum et al. (2005) acknowledge, the number of axes, or parameters, and the values that are assigned to them, may be based on subjective selection. I selected the axes and the values according to my first-hand experience as a performer on Kurenniemi's instruments. Typically, the dimension space axes occupy several values per parameter, although here I restrict the number to three (see Table 2). More finely grained data collection would require a more systematic approach than my subjective take on each instrument and its usability. Moreover, additional users from different backgrounds should be used to test the instruments and thereby to gain more data for enhanced interpretation. Despite the subjective point of departure, however, the research design unwraps the usability issues connected with Kurenniemi's instruments in a systematic manner. Primarily, the data set and its visualizations presented in Chapter 6[63] serve as a reference point directing the reader to the historical descriptions of user stories in Chapter 7. Additionally, the presentation serves as preliminary data and material for pilot testing the research design for future purposes. The further development of the tool is beyond the scope of this study.

Table 2. The parameters and values for charting the user interfaces and functionalities of Kurenniemi's electronic musical instruments: I return to the parameters and values in more detail in the analytical section of this study (see Chapter 6.2).

Parameter No.	Interface features	Values; No.	Values; Natural Language Definitions
0	Short description	[n/a]	Short verbal description of the interface
1	Physicality	1;2;3	Physical; Both; Virtual
2	Tactility	1;2;3	Tactile; Both; Non-tactile
3	Readability	1;2;3	Clearly readable; Partially readable; Non-readable
4	Comprehensibility	1;2;3	Comprehensible (see what you get/hear); Comp w/ extensive learning; Non-descriptive (verified only by audio feedback)
5	Controllability	1;2;3	All parameters available; Some parameters available; No parameters available
6	Intonation/tuning	1;2;3	Fully flexible tuning; Constraints can be manipulated with abuse; Constrained to chromatic scale
7	Timbral flexibility	1;2;3	Fully flexible sound manipulation; Some features can be adjusted; Constrained to the instrument's sound
8	Venue	1;2;3	Live; Both; Studio
9	Initial purpose	1;2	General-purpose; Case-specific
10	Accessibility	1;2;3	Easy to use; Somewhat easy to use; Requires extensive learning
11	Programming	1;2;3	Real-time control; Both; Pre-programmed

[63] Dimension space visualizations for each of Kurenniemi's instruments are presented in Chapter 6, see Figures 62–70. The charting material and data are available as *The User Interface and Functionality Charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* data set publication in Electronic Musical Instruments by the Erkki Kurenniemi community in Zenodo (see: https://doi.org/10.5281/zenodo.2089416).

It is noteworthy that the descriptions of dimension space are applicable only to one specific developmental state of the design at a time, such as designer's initial-level idea of the instrument. User modifications and experimentation challenge the description, thus updated versions of the dimension spaces should be drawn. Already-tested and mass-produced artifacts acquire new uses and meanings through being used – even after a prolonged period. Here, my methodological approach leans on the idea of *interpretative flexibility* from the SCOT context (see also Chapter 2.2.2). Within this study, I anchor the description to the historical situation and avoid hindsight. Recent research and artistic projects on Kurenniemi's instruments have revealed the new sonic potential, which was unthinkable to contemporary historical users.

3.3 The analysis of electroacoustic music

As I note in previous sections, conducting a research project is an intensive interplay between the research task, the questions, the material, as well as the chosen tools and methods used to answer the questions. The is also true of music analysis: the research task and questions determine the analytical frame and the necessary tools for the analysis. The purpose of music analysis is both to describe and interpret musical works as well as to develop tools that facilitate comparison and discussion. The aim is thus to dissect the works into significant pieces (i.e. pertinences) and synthesize an informed and critical interpretation of them, but it is also a balancing act between descriptions of the material reality of the work, and its poietic and esthesic processes. (see Bent 1987; Padilla 1996; 1997; Emmerson & Landy 2016, 9)

As composer Jean-Claude Risset (2002, xvii) states, works cannot be subjected to "blind and automatic dissection according to a prior principle", but "each work requires its own approach, which may yield surprises." A certain systematic method or consistent language is required to compare the works in question. In this sense, the analysis of electroacoustic music is about choosing suitable tools in relation to both the work at hand and the target of the research. Thus, the crucial question is: What do we want to say about these works? Not all aspects can be analyzed at once, thus analysts need to select according to their own intentions. Answering the question may also facilitate the framing of the research project. (see e.g. Emmerson & Landy 2016, 9–11; see also Camilleri & Smalley 1998)

My key analytical question here is this: What can these works tell us about the technology used in their realization? In addition to providing answers, the material collection and the musical analysis are intended to enrich the previously outlined historical presentation. In mapping the points of departure I return to the tripartition model developed by Nattiez, presented in Chapter 2.3.2 (see Figure 7). Music analysis is interpretation, which is profoundly dependent on the point of departure. The interpretation differs depending on how the musical work is perceived: 1) as material reality, 2) as an outcome of the intention of its composer affected by the circumstances of its birth, 3) as an object that is both defined by and influences its receiver, or 4) as a performance.

Nattiez's model was later revised by Emmerson (1982) and Padilla (1996; 1997), for example. According to Nattiez's (1990, 100–101) guidelines, musical analysis necessarily starts with "a material level description of the work", in other words "an analysis of its neutral level". However, the work is always accessed through interpretation, even on its neutral level (see Demers 2010, 5; see also my remark in Chapter 2.1 above on how this resembles Megill's unresolved tension as a historiographical paradigm).

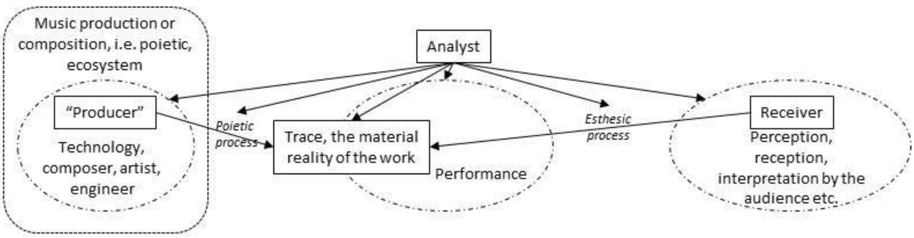

Figure 7. Nattiez's (1975, 52; 1990, 17) tripartition model from the perspective of the potential analyst, complemented with a performance aspect (Padilla 1997, 149), and emphasized with the description of poietic ecosystem (Image: Ojanen 2019)

I employ Nattiez's model here only as an analytical framework. Tripartition helps me to dissect and direct my analytical points of view. The point of departure of my scrutiny is both the material level of the work and the composer's description of poietic ecosystems. From these descriptions, having identified the relevant features (*pertinences*) of the works by analytical means, I interpret the historical use situations of Kurenniemi's instruments. As an outcome of the material and data collection, I also comment on the esthesic side of historical description even though it is not emphasized in this work.

In Nattiez's model, the poietic process in particular does not sufficiently describe the technology-driven process. Interaction with an instrument in technology-oriented processes could set the focus and intention of the composer in a different location than traditionally intended. For example, the random process of instrument testing or editing tape collages without a predetermined plan exemplifies how the focus of a composer shifts from the sonic outcome as a composition to the design of the instrument, for example. Given the nature of technology-driven music production, there is a risk of describing details of a work that are of little significance, or even contradictory when it is approached from another perspective. One can receive, analyze, interpret and even enjoy music with or without prior knowledge of the poietic process, the composer's intention or the rules dictated by the genre. However, even though knowing how the work was realized is not a necessary condition for music analysis, knowing the poietic process of the analyzed work alters the interpretation.

Emmerson & Landy (2016, 22) describe this as *poietic leakage*. They also point out that most previous analyses of electroacoustic music concentrated on the poietic side of the works and welcome an emphasis on the listener's side in future analyses. To elaborate further on the idea of *poietic leakage*, I will take a cue from the analytical framework or research practice termed Historically Informed Performance.[64] I would describe the analytical approach I employ here as technologically informed analysis. Whereas HIP aims at historical accuracy in performances of early music, I aim at historically and *technologically informed analysis* of electroacoustic music and electronic musical instruments. The point of departure for the analysis is the material reality of the objects and the poietic process, which I describe as a *poietic ecosystem*.

Analysis of the esthesic process, however, is two-sided, in that perception should be distinguished from reception. On the one hand, just as Demers (2010) distinguishes aesthetics from critique, there is perception of the work, which is the esthesic process (an individual experience of the receiver), and on the other hand there is its reception. The latter refers to how the work was received by the audience when presented in a concert, or released on record, for example.

A typical feature of electroacoustic music is that the works exist only as audio recordings, as software or hardware patches, or in various forms of contemporary documentary evidence. Composers rarely outline scores or give written instructions. Their works are realized in close interaction with the production technology as *bottom-up compositions* (see Emmerson & Landy 2016, 10), or in real-time performance with the equipment rather than according to a prescribe score. The non-existence of a score constitutes a challenge to music analysts compared with the traditional setting. The primary source for the analysis is aural perception, therefore various listening-based approaches have been developed with regard to electroacoustic music. It is noteworthy that the situation differs only a little from ethnomusicological fieldwork. Another analytical challenge is that the fundamental material of electroacoustic music does not comprise units as clearly outlined as notes, but rather consists of arbitrarily defined sonic objects such as any imaginable sound, sounds beyond imagination, or even silence. Moreover, the relationships between the fundamental units of electroacoustic music do not yet follow similar traditions as in note-based music.

To present the "immanent sonorous configurations of the work" (Nattiez 1990, 61) and to overcome the lack of a score, various visual presentations, both descriptive and symbolic, have been used in the analysis of electroacoustic music. Methods of outlining a descriptive score vary widely. One of

[64] HIP; see, for example: https://sohipboston.squarespace.com/what-is-hip/

the earliest scores is Reiner Wehringer's visual listening score of György Ligeti's *Artikulation* (1958), completed in 1970[65] (Holmes 2012, 370). Robert Cogan (1984) introduced sonograms for visualizing musical sounds in the 1980s, tools that were similar to those used previously to visualize speech sounds in phonetics. Sonograms provide the music researcher with a tool for comparing differences in the interpretation of one work by different performers (ibid., 49–56), for example, whereas for the electroacoustic music analyst they provide "a notation that clearly specifies - - - the orientation, motion, duration, and spectral makeup of each element of the music" and "an analytic base, with data and evidence, for conclusions about the sonic character and structural function of the sonorities and features that they picture" (ibid., 103).[66] I use the word *sonogram* in this study, which is widely used in Europe and is equivalent to spectrogram.

Landy (2007, 203) considers a sonogram a good point of analytical departure, but questions its role as part of the analytical process: He asks, "can we hear everything that we see in these images? Of the information, we cannot perceive how relevant is it in the end?" When setting up their analytical toolbox Emmerson & Landy (2016, 9) also emphasized the "aspects of the work *that can be heard* – not those that can *only* be detected by machines." Sonograms can produce a seemingly objective presentation of a sound recording, but certain aspects affect the image they depict. Even at the stage of choosing the parameters for the software that is used to draw the image, the interpreter influences the process: in scaling the sonogram he or she alters the picture and may drive perceptions in a certain direction. Moreover, details starting from the digitization of the analog tape and the production of the image affect the sonogram as an "objective scaffold", and as a point of departure for analysis (see Ojanen 2015).

Here, I see the sonogram as a notebook frame in which listening-based annotation, in other words a descriptive listening score, can be outlined. Using a sonogram helps me to keep the analysis transparent. I proceed in my analysis as follows. 1) Because there is rarely a score for the works, my primary analytical source is the audio recording. 2) When digitizing the audio material myself, I follow a critical digitization process (see Ojanen 2015), which I document as accurately as possible. During the course of the study I piloted the video recording of the running tapes[67] and the research-driven metadata production,[68] which may facilitate the implementation of Digital

[65] See Craig (2007).

[66] For more information about the visualization methods of electroacoustic music and music signals in general, see Simoni (2006), Adams (2006), or Lassfolk (2013b).

[67] See an annotated video of the master tape of the Arrangement of J.S. Bach's Invention No. 13 in A minor (BWV 784) for the DIMI-A synthesizer by Erkki Kurenniemi (1970): https://vimeo.com/278832133; see also the other documents at: http://doi.org/10.5281/zenodo.1469722.

[68] Ojanen, Mikko. (2019). Preliminary metadata for the UHMRL digital tape archive pilot (Version 20191223_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3591336.

Humanities research methods in the future. 3) I based my content analysis of the work on critical and analytical listening, facilitated by 4) a sonogram as a scaffold for annotation. 5) The annotation based on critical listening includes structural analysis, the categorization of instruments used and sources if recognized, and a description of their role as well as of the sounds and sound families, if I consider them significant. 6) I sketch a description of the poietic ecosystem in which the work was produced, if possible. 7) I also consider the relationship of the musical work with performance and improvisation, meaning that I follow Goehr's (1992, 186) advice and do not conflate music and musical works. The analyses of user stories in Chapter 7 are based mainly on the key findings of the music analysis. The historical description and interpretation in Chapter 5 also benefit from the music analysis, even though I do not explicitly refer to the results of the process in the narrative.

4 PRECONDITIONS FOR ELECTROACOUSTIC MUSIC AND INSTRUMENT DESIGN

Kurenniemi's instrument design did not appear out of thin air. My aim in this chapter is to outline the background of his design environment, and to identify the key developmental lines of the overall global situation before the 1960s (Chapter 4.1), as well as the local situation in Finland. It is neither necessary nor possible to go into more detail about global developments. The early phases of this music style as they evolved in Finland deserve closer scrutiny (Chapter 4.2). Several authors have studied the history of electroacoustic music and have written about it on various occasions. Here, I lean mainly on the presentations of Chadabe (1997), Holmes (2012), and Manning (2013).

4.1 An overview of the global history of electroacoustic music and instrument design

The preconditions for the musical style known as electroacoustic music, which surfaced during the late 1950s, included the emergence and development of 1) sound recording and processing technology, and 2) *electronic* musical instruments and computer technology. In addition, 3) the development of the Western classical-music tradition in the late-19th-century and the first half of the 20th, and 4) the domestication of noise and silence as primary musical material provided a fertile background for electroacoustic music. Stages in the development of 20th-century Western music include the melodic and harmonic phase from late-19th-century Impressionism to atonality, from atonality to dodecaphony, and eventually to integral serialism, of which the *elektronische Musik* produced in Cologne is a typical example. At the same time, experimentation, musical happenings and performance-art aesthetics strongly influenced the development of electroacoustic music.

One of the preconditions for the new musical aesthetics was the invention of sound recording. Being able to record sound fundamentally changed the way it was stored, transferred, and studied, and facilitated the reproduction and repetition of unique performances, as well as sound manipulation. After the invention of the gramophone, a musical performance could be detached from its origin. Several scholars have carried our comprehensive studies on the origins of sound recording and its influence on musical aesthetics and activity (see Sterne 2003; Katz 2010).

A few details of this development with specific relevance to the context of this study include the notion of a *studio as an instrument* and as a *compositional tool*. The concept of a studio has developed, from being a place for recording to becoming an instrument for a composer (compose *for* an instrument), and even a compositional tool (compose *with* an instrument). The idea of using sound-recording technology in a creative setting arose in the early days. Katz (2010, 109–123) traced the emergence of theoretical writing on the topic, starting from the 1910s. Concrete experimentation with the technology goes back at least to the 1930s when Igor Stravinsky, Ernst Toch and Paul Hindemith anticipated and tested the potential use of a gramophone as a musical instrument (Katz 2010, 109–123; Taylor et al. 2012, 110–113).

In their review of a collection of historical documents on the early days of the phonograph, cinema and radio, Taylor et al. (2012, 110–113) classify two texts under the heading The Phonograph as a Compositional Tool. In the first of these, which was written in 1930, composer Igor Stravinsky hails the potential of the phonograph and eagerly anticipates having the opportunity to create music that "--- could only be preserved through mechanical reproduction." Stravinsky's vision exemplifies how the medium could provide sound storage and function as a creative tool. Later, in the early 1960s, the theme was embraced by composers such as Morton Subotnick (in Bernstein 2008, 112–114), who considered his art to be studio art. In Finland, Salmenhaara referred to Kurenniemi using his studio as an instrument when producing his first standalone tape music work *On-Off* (1963) in 1964.[69]

As sound recording and production technology developed and became an instrument of artistic creativity, various changes were gradually taking place. The most notable of these was that a prescribed score was not necessary. The new way of working in interaction with instruments shifted the composer's focus from laying out a predetermined plan or score to the immediate process of aesthetic decision-making and listening to the direct sonic output of the musical instruments: in some cases the composer was able to interact with his or her instrument in real time. Furthermore, with the development of studio technology, composition and music production have diverged from a linear workflow to an integrated process in which previously discrete tasks such as composition, arrangement, mixing, mastering and eventually distribution are combined into a single iterative effort (see also Ojanen 2015).

These new means of manipulating sound and advances in sound-processing technology were preconditions for the development of electroacoustic music. In particular, they were integrated into the tradition of *musique concrète* – a musical style founded by French composer and sound engineer Pierre Schaeffer. Even though sound-recording technology provided the technological basis, it does not fully describe the genre. It enabled

[69] Salmenhaara (1964, 55).

Schaeffer's experimentation, but his point of departure for composition was in the material used for musical works rather than the technology. He abstracted musical structures and meaning from raw sound material with the help of the new sound-recording and processing technology. In this respect, musique concrète laid the foundations for the bottom-up compositional paradigm (I borrow the term bottom-up from Emmerson & Landy 2016, 10). Schaeffer formulated his experiments into a theory, which he presents in his cornerstone publication *Traité des objets musicaux* (1966): this is considered a classic in the literature on electroacoustic music, and inspired the later development of various styles such as acousmatic music (see Schaeffer 2017).

The early phase of electroacoustic music is typically represented in two European schools, the French *musique concrète* and the German *elektronische Musik*. The difference between the two typically lies in the sound material used in the respective works. As Emmerson (1986, 36) insightfully states: it "is a gross simplification to imply that Stockhausen's *Gesang der Jünglinge*, in using the recording of a boy's voice in part of the material, broke the barriers between the two groups." The two schools had strikingly different points of departure for their compositions. Whereas musique concrète was based on the bottom-up process initiated by features in the sound material, the origin of elektronische Musik can be traced to the stylistic development of Western art music starting from the late-19th-century, which was based on top-down processing.

The stylistic development of music, from early Romanticism to Impressionism and Expressionism, later took a turn toward atonal music and dodecaphony. The climax of this development was in integral (or total) serialism based on the idea that all musical parameters could be predetermined by the composer beforehand. Here, great expectations were placed on the new technology, which allowed the use of discrete oscillators with precisely adjustable frequencies, and tape recorders with precisely editable sound segments, in realizing the composer's prescribed musical scores. The point of departure for the composition process was theoretical and contrasted significantly with the bottom-up compositional premises of musique concrète.

Other overarching themes behind the development of electroacoustic music include the domestication of noise and experimentation within different art forms. During the early phases it was integrally experimental. Given the lack of dedicated technology, almost any technological artifact qualified as a point of departure for testing and experimenting with sound production and processing: examples include various types of sound-recording devices and equipment designed in the field of communication technology or for scientific purposes such as laboratory measurement. It is worth pointing out that noise has always been a significant component of music, exemplified in the spectrum of cymbal sounds. In this case, however, it had a secondary role as part of other musical material. Starting from the 1910s with the experiments and tenets of Italian futurists and American composer Edgar Varèse, noise came to be considered primary musical material.

High expectations were not restricted to sound-recording and processing technology, and also covered the automation of musical processes that started with barrel organs and player pianos. This development continued in the electronic age when various kinds of automated instruments were anticipated as a solution to the problem. In this context, the notion of computer-aided composition originated in the drive to automate traditional tape-manipulation techniques such as cutting, copying, pasting and splicing, which are time-consuming and laborious. In addition to automating the mechanical process, however, expectations extended to the production of new musical processes according to preset rules, or algorithms. Essl (2007, 107) defines an algorithm as "a predetermined set of instructions for solving a specific problem in a limited number of steps." Algorithmic music has a long history dating back to Pythagoras and the Jewish Kabbalah, but algorithmic composition only became popular with the development of computers.

The first tests of computer music were run on general-purpose computers such as the Australian CSIRAC (see Doornbusch 2004) and the RCA's programmable synthesizer. During these tests the computer either performed previously composed popular music tunes or produced musical scores according the algorithm outlined by the programmer to be performed by a traditional music ensemble – such as the *Illiac Suite* (1957) for string quartet programmed by Lejaren Hiller and Leonard Isaacson. The first genuinely computer-generated and performed works – including *Analog #1: Noise Study* (1961) by James Tenney at Bell Labs – were produced at the turn of the 1960s. Composing with a computer was not straightforward, however, and required several steps before the composer could hear the final outcome. A major shortcoming of computerized music production was the slow program-writing and digital-to-analog-conversion process, which could take weeks. Chadabe (1997, 112–115) gives a vivid description of it.

The next step forward was the development of special-purpose musical sequencers. Kurenniemi was also working with the idea of an automated music machine to overcome the time-consuming tape splicing. The topic was commonly pondered on at the time, and tape-manipulation techniques were already declared obsolete at the turn of the 1960s – at least according to far-reaching utopian envisioning.[70] Notably, technological idealism and feasible implementation were far apart. Kurenniemi frequently discussed the issue with contemporaries such as Swedish composer Leo Nilsson,[71] and early sequencer designs by an American instrument designer were produced to remedy the situation (Pinch & Trocco 2002a, 40).[72] Buchla had several discussions with composers Morton Subotnick and Ramon Sender when they were working on improving the burdensome tape-manipulation process (see the interview with Subotnick in Bernstein 2008). Sequencers did eventually pro-

[70] See Heikinheimo (1967, 20/*HS* October 29, 1967).
[71] Nilsson (2019) in an interview with Ojanen.
[72] Buchla Associates (1966).

vide a solution to tape-splicing – at least in part. As simple and straightforward mechanical devices they did not yet meet the complex demands related to the management of musical material, such as copying and pasting musical passages. The early models resembled analog computers and their memory equaled their physical patches, which could not be stored or copied.

4.2 The early development of electroacoustic music in Finland

Even though Finnish composers first came into contact with European trends in the mid-1950s when they started to participate in Darmstadt International Summer Courses for New Music (see the list of participants in Heiniö 1986, 55), the main trends never landed in Finland in their pure form. The overall development of electroacoustic music in the country was slow (Heiniö 1986, 56). When electronic media began to penetrate the Finnish music scene, a significant role was played by members of the radical young generation of musicians and composers who absorbed influences freely. They protested consciously against tradition. The various visits of contemporary composers such as Stockhausen (1958, 1961 and 1962), Luigi Nono (1962 and 1963), John Cage (1964), and György Ligeti (1965) strongly inspired Finnish audiences (Heiniö 1988, 25). A total of 750 people attended Stockhausen's lectures in Helsinki and Turku in 1958.[73] The conversation in the press about contemporary music was lively, and there were frequent radio broadcasts of international works. Finnish composers were nevertheless held back by limited resources – both technological and financial (Heiniö 1986, 56).

Although electronic sound effects were frequently used in radio plays (see the chronical list of works of Finnish origin in Kuljuntausta 2008, 332–357), the first official electroacoustic works composed in Finland were Martti Vuorenjuuri's *Uljas uusi maailma*, a radiophonic adaptation of Aldous Huxley's (1958) *Brave New World* lasting over an hour, and Bengt Johansson's *Kolme elektronista etydiä* (1960; Engl. Three Electronic Studies). It was eight years before Vuorenjuuri's work had its first public performance, delayed by licensing issues concerning the movie rights for Huxley's book. Only one private performance was arranged in 1959, which was for the press and invited guests. Johansson's work was first premiered in 1960, and later in a tape music concert of modern music at the Jyväskylän Kesä festival in 1963. (Heiniö 1995, 179–181; Ruohomäki (2020, EH14/1–5) According to Kuljuntausta (2008, 308), most Finnish electronic works were heard only once or twice, and overall public access to them was restricted. Other active composers during the early years were Erkki Salmenhaara (1941–2002), Henrik Otto Donner, Reijo Jyrkiäinen (b. 1934), and Erkki Kurenniemi.

[73] See Stockhausen (1958/*HS* April 16, 1958).

Suomen Musiikkinuoriso (Engl. the Finnish Musical Youth Association) played a pivotal role in introducing electronic music to Finland. It was behind the regularly broadcast radio program *Musica Nova*, and its members wrote and edited several issues of *Kirkko ja Musiikki* (Engl. Church and Music) magazine, a periodical that soon became the voice of the new music. Even though the association was founded in 1957, the first concert performance was not until December 1962. The year following the concert was eventful and is considered a watershed period in the history of electroacoustic music in Finland. Suomen Musiikkinuoriso organized over ten concerts in 1962-63, and its members were responsible for most of the electroacoustic works composed in Finland in 1963. The association was dissolved in 1965 when its members chose to go in their own directions and Yle started to take a stronger role in broadcasting electronic and experimental music in its programs. (Heiniö 1988, 25–28; Ruohomäki 2020, EH14/1–19 and EH26/1–6)[74]

It is suggested that the early development of electroacoustic music in Finland occurred in two phases – sometimes described as two waves. Depending on the viewpoint, the first intensive period ended in the mid-1960s and the second one evolved gradually over the following decades.[75] (Lång 1990; Ruohomäki 1998, 33; Kuljuntausta 2008, 304; Ojanen 2014b, 151) Although this is an accurate estimation in terms of the number of works composed and concerts organized in Finland during that time, work on the grassroots level never fully stopped. The phased development is not surprising, and intensive bursts such as the higher levels of concert and composition activity in 1963 reflect the new generation's search for novel aesthetic expressions and attempts to break from tradition, which Heiniö (1988; 1995, 178) aptly describes as a "period of exploration".

The concert settings and the interdisciplinary art happenings were the primary playgrounds for experimentation with recent technology and finding a new kind of aesthetic expression. From the very early days, electroacoustic music and experimentation with electronic media went beyond the traditional concert setting – and during its first decade strongly towards sound art. Moreover, the 1960s saw a shift from avant-garde to underground, and from happenings to intermedia[76] art. Interestingly, a similar attempt to break out from tradition that arose from the experiments of Suomen Musiikkinuoriso is

[74] See also Salmenhaara (1975) in an interview with Sermilä.

[75] See also Salmenhaara (1969, 16 / *HS* November 19, 1969), who considers that the concert *Electrcononstop* on November 17, 1969 marks the new beginning for the genre in Finland.

[76] I understand *intermedia* here as it was employed at the time – especially as J. O. Mallander used it in *Iiris* magazine: he refers to Dick Higgins and the Fluxus movement in the avant-garde art scene in New York, where its roots go back to the late 1950s. When I use the term here, I recognize that not every work of art employing various media (such as sound, picture, staging, film) can be considered an intermedia work, opera being one example. Later on, intermediality was defined slightly differently and used especially in literature studies (see e.g. Rajewsky 2005; Jensen 2016).

implied in the declaration of visual artist and experimental film director Eino Ruutsalo (1921–2001) in 1968 (Laiho 1982, 17; Home 2013, 17).

As Heiniö (1988) argues, the 1960s was a period of pluralism. For many composers and artists, electronic technology was as much a tool for aesthetic expression as a traditional instrument. This is evident in the comments of composers Henrik Otto Donner and Erkki Salmenhaara. Donner, who had a "utilitarian attitude towards technology", was only interested in the sounds one can produce with it, not in how the technology works.[77] According to Salmenhaara, writing in 1969: "technical devices have the same position in electronic music as instruments in traditional music", thus "technology is merely an instrument to produce all the necessary sounds, but it does not determine the musical structure in any way."[78]

4.2.1 Challenging the traditional organization of a concert setting

Donner became acquainted with many leading contemporary European composers and avant-garde artists during his travels in the early 1960s, introducing himself to modern composition methods including serialism and the techniques of both elektronische Musik and *musique concrète* (Ruohomäki 2013, 6–7). These experiences had a strong influence on his works. However, being also and foremost a composer of jazz music, he used different compositional techniques very freely. He later abandoned electronic means in his music altogether, partly because of the mediocre quality of the technology.[79]

Donner experimented with spatial sound and audience participation in his early works, especially in *Ideogramme I & II* (1962–63). Both versions of the work are based on the same idea: how much the message can be disturbed before it loses its meaning. Along with the obvious influence of Cage, his main inspiration came from information theory, which was current at the time. In line with some of his contemporaries, Donner brought the idea to the musical context and tested how the players' synchronization and concentration could be distracted by different electronic means. *Ideogramme I & II* were the first works in Finland in which musicians played along with a prerecorded tape. (Ruohomäki 2013, 7–8)

The instrumental part of *Ideogramme I & II* consists of notation instructing players to play as high and as low pitches as possible, to stomp with their feet and to shout. The timeline is organized as a second-per-bar notation, and players follow the score with a stopwatch. The score and the tape part for *Ideogramme I* exist in the composer's private archive. Large-scale instrument parts for both versions and a radio map for *Ideogramme I* are in the

[77] Donner (2013) in an interview with Home & Ojanen.
[78] See Salmenhaara (1968, 208).
[79] Donner (2013) in an interview with Home & Ojanen.

archive of Music Finland (MF No. 994, *Ideogramme I*[80]; MF No. 582, *Ideogramme II*[81]).

Ideogramme I is for four instruments (fl, cl, trb, perc) and electronics. The first version was premiered in the first concert organized by Suomen Musiikkinuoriso in the small concert hall of the Sibelius Academy in December 1962. The electronic part was realized via twelve radios, which turned out to be too low in volume, and Donner decided to replace them with a tape for the second concert performance held in February 1963. (Heikinheimo in Ruohomäki 2013, 8) The tape part consists of filtered noise.

Ideogramme II was realized for the architecture exhibition Suomi Rakentaa (Engl. Finland is building), organized in Taidehalli (Kunsthalle) in Helsinki, April 1964. It was the first work in Finland to use live music in an exhibition (Ruohomäki 2013, 8). According to Heiniö (1988, 36), it is likely that Donner was aware of Karlheinz Stockhausen and Mary Bauermeister's project to merge music and exhibition. Donner raised the number of players to 20 for *Ideogramme II* and realized the electronics with a dual mono tape recorder. The tape consisted of electronically processed noise, instrumental sound, and speech (Oramo in Heiniö 1988, 36). At an exact moment in the score the players are instructed to play any famous concerto or symphony written for their instrument. Audience participation is highlighted in *Ideogramme II*, which it is not in *Ideogramme I*. The players and two pairs of loudspeakers were distributed in different rooms in Taidehalli. The audience could wander in and around the work and thus had different perspectives on it. The tape parts were realized in the University Studio.

Audience participation and the spatial distribution of sound were also key features in Donner's *For Emmy 2*, which was premiered at the Sabotage concert, the last concert organized by Suomen Musiikkinuoriso, in Ritarihuone (The House of Nobility) on October 18, 1963. Apart from the loudspeakers and amplification of the acoustical instruments, electronics did not feature in the work, nevertheless it challenged the traditional concept of a concert ritual. The players started playing when the audience was coming in and continued to improvise while walking out of the concert hall at the end of the piece. Applause was written as part of the work. Kurenniemi recorded the work, and the sound recording exists in the Music Finland archive.[82]

4.2.2 Live processed instrumentation and experiments with sound spatialization

As Donner was compiling his early works, Erkki Salmenhaara was experimenting with spatial sound in a concert setting in *Pan ja Kaiku* (1963, Pan and Echo) and *Concerto per due violini* (1963, Concerto for two violins).

[80] See: https://core.musicfinland.fi/works/ideogramme-i
[81] See: https://core.musicfinland.fi/works/ideogramme-ii
[82] See: https://core.musicfinland.fi/works/for-emmy-2

Moreover, Salmenhaara's works were the first in Finland to include live processed acoustic instruments – the former was composed for four cymbals and a tam-tam. Along with Donner, he was among the radical composers of Suomen Musiikkinuoriso. He composed large-scale productions in which his electroacoustic and live electronic works are sidetracked, being only one aspect of the experimentalism that interested him at the time. Later he withdrew some of his early experimental works and forbade their performance, although he had restored them by the mid-1990s. (Heiniö 1988, 42–44; Ruohomäki 2020, EH24/1; Uimonen 2007, 85–87)

Pan ja Kaiku and *Concerto per due violini* have a similar performance setup. The instruments are located on the stage and the loudspeakers at the back of the hall behind the audience. This produces a static but somewhat heterogeneous spatial effect in that dry instrument signals are in front and their processed counterparts come from behind. The score of *Concerto per due violini* is available in the archive of Music Finland (MF No.1039[83]). *Pan ja Kaiku* was performed only once, in April 1963, whereas *Concerto per due violini* had two performances, the premiere at the Jyväskylän Kesä festival in July 1963 and the second one at the Sabotage concert in October 1963. A monophonic recording of the premiere exists in the archive of the Finnish Broadcasting Company (Yle).

The score of *Concerto per due violini* consists of a graphic second notation with instructions for expressions and dynamics, but no note information. Graphic lines and blocks on the score refer only to the string to be played at a given moment. There are separate instructions on the second page of the score for live processing, i.e. amplification (or distortion in this case, judging from the surviving recording) and reverberation (at least 10 seconds according to the performance instructions). The general performance instructions include remarks such as:

- the work is performed with untuned violins
- players should avoid any tonal material
- violins are equipped with electric-guitar microphones connected to the bridge.

Salmenhaara's radical initial attempt to realize an intentionally raw and ugly composition did not fully succeed. As Palas states (in Heiniö 1988, 44): "in the hands of the professional musicians the end result turned out to be instinctively tonal". As Uimonen (2007, 87) aptly observes, this feature gives the work an indeterminist slant, and the performance is strongly based on the musicians' personal musical conceptions given that the exact note information is left undefined in the score.

[83] See: https://core.musicfinland.fi/works/concerto-per-due-violini

4.2.3 Early studios for electroacoustic music in Finland

Most of the early electronic music studios were built by public broadcasting companies and university departments. According to the canonized view of electronic music, the first studios proper were in Paris, Cologne, and Milan. Referring to the early situation in Europe, Davies[84] acknowledges the existence of the University Studio in Helsinki. Holmes (2012, 92–93) lists nineteen studios, but fails to mention the situation in Finland. Seventeen of the studio constructions in Holmes's list were founded between approximately five and ten years before the University Studio was designed and constructed, and two coincide with it.[85]

The first experiments aimed at building an electronic music studio in Finland were conducted at the turn of the 1960s within the Finnish Broadcasting Company, Yle. Even though Yle's Tehosto sound-effect archive dates back to 1957, regular experimental activity such as radiophonic seminars started around the mid-1960s, and the first permanent studio premises were built as late as in 1973. Before there was any permanent activity the studio constructions were temporary and lasted for only a few months. These studio setups were constructed to allow composers to carry out specific projects, and they were dismantled when the work was completed. Following on from Martti Vuorenjuuri and Bengt Johansson, in 1963 composer Reijo Jyrkiäinen built a temporary studio facility in Yle to realize works such as *Sounds I* and *II* and *Idiopostic I*.[86] (Kuljuntausta 2008, 88–101; 132–140; 176–184; 263–271; Tamminen 2017)

The construction of two parallel studio facilities in the early 1960s – for Jyrkiäinen in Yle and for Kurenniemi at the University of Helsinki – attracted attention, and some composers and artists expressed concern about the situation. Donner was of the opinion that, instead of building two mediocre facilities, all available resources should be focused on the construction of one excellent studio.[87] These parallel projects reflect the status of electroacoustic music in Finland at the time. In effect, only a handful of people were interested in the new art form, and they did not include the organizations that had had the necessary resources.

The experimental productions of the time were small underground projects that were realized with modest resources. One of the active figures in the field was visual artist and experimental film director Eino Ruutsalo, who commissioned soundtracks for his films from Donner and Kurenniemi. The

[84] Davies (1968).

[85] For more information on the history of electronic music studios, see Schaeffer 1963 and the collection of studio reports in the *Journal of Music Theory* 1963 7 (1); Wiggen 1972 and the collection of studio reports in Interface 1972/1; Schedel 2007; Niebur 2010; Böhme-Mehner 2011 and the special issue of GDR electroacoustic music in *Contemporary Music Review*; Holmes 2012; Manning 2013.

[86] See Sirén (1976, 52–53).

[87] *Hbl* (August 17, 1963, 1; 8).

music and soundtracks were produced in several different studios. Ruutsalo had a bunker studio for editing the soundtracks on Iso Roobertinkatu in the center of Helsinki. Musician Kaarlo Kaartinen, who frequently played in Ruutsalo's projects, also had a modest studio facility named Cinevox. Donner had access to an even more professional recording studio, Elektrovox, owned by Akkuteollisuus Ltd., which was also used by Toivo Kärki and other leading names on the Finnish popular-music scene (on the history of studios in Finland see Muikku 2001, 269–282). The soundtracks for the films *Kaksi kanaa* (1963; Engl. Two Chickens) and *Hyppy* (1965; Engl. The Jump) were produced in the University Studio.

5 A HISTORY OF KURENNIEMI'S ELECTRONIC MUSICAL INSTRUMENTS

This chapter charts the history of Kurenniemi's instruments and the University of Helsinki Electronic Music Studio, which I consider Kurenniemi's first instrument-design project. I focus on how Kurenniemi designed his instruments, when he built them, who used them, and how the users participated in the design process. His instruments have been identified, their locations are known, and most of them have been restored and are in working condition. Various detailed descriptions of the instruments and their design have been published (see Ojanen & Suominen 2005; Ojanen et al. 2007; Städje 2009; 2012; 2013 ; 2017; Suominen 2013; Lassfolk et al. 2014; 2015). However, given that new source material has appeared and, in particular, that extensive restoration projects initiated by Jari Lehtinen and Jari Suominen during the last 15 years[88] have enhanced understanding of the instruments, it is appropriate to review the history again.

Kurenniemi built electronic musical instruments and studio equipment between the years of 1964 and 1975 (see Table 3). His projects fall into three categories: 1) the electronic music studio of the University of Helsinki, including the Integrated Synthesizer (1964); 2) custom-designed instruments, including Sähkökvartetti (Electric quartet) (1968), the Andromatic (1968) and the DICO (1969); 3) instruments developed during the Digelius period (1970–1975) known as the DIMI (Digital Musical Instrument) series, which include synthesizers (the DIMI-A, the DIMI-O, and the DIMI 6000), biofeedback-based musical instruments, also likened to musical toys (the DIMI-S and the DIMI-T; see Suominen 2013, 151), and studio equipment (the DIMIX). Kurenniemi's two ambitious design projects (DIMI-P and DIMI-U) exist only as hand-drawn sketches on paper and not a single unit was built. Kurenniemi returned to designing musical instruments in the early 2000s and completed the DIMI-H (2005), which is based on his mathematical theory of musical harmonies. Even though neither the DIMI-P nor the DIMI-U materialized, and the DIMI-H falls beyond the scope of this study, I include them in the table to give a comprehensive presentation.

[88] The restoration projects included: Sähkökvartetti and the DIMI-O (Jari Lehtinen, 2002), the DICO (Jari Lehtinen, 2003), maintenance of the DIMI-A and the DIMI-O (Jari Lehtinen, 2013–14), "DIMI is reborn": replication of the DIMI-A (Jari Suominen, 2014), restoration of the Integrated Synthesizer generator unit (Jari Suominen 2017–2018; see Suominen, Jari. (2020). Erkki Kurenniemi's Integrated Synthesizer – User Manual of the Generator Unit. Zenodo. https://doi.org/10.5281/zenodo.3600460).

Table 3. An overview of Kurenniemi's electronic musical instruments (Ojanen et al. 2007, 89 with a few updates).

Instrument (and the origin of the name)	Year	Qty	Description
The 1st digital music system (later known as sähkö-ääni-kone (Electric sound machine), System-1 or Integrated Synthesizer)	1964–68	1	Three-piece modular synthesizer and sound processor unit with digital and analog modules
Electric quartet	1968	1	Collective instrument for four players with mobile controllers and a 10-step sequencer
Andromatic (automatic Andromedean)	1968	1	Polyphonic synthesizer with a 10-step sequencer
DICO (digitally controlled oscillator)	1969	1	Monophonic synthesizer with a 12-step sequencer and digital memory
DIMI-A (associative memory)	1970	2	Two-voice synthesizer with a 256-step sequencer and digital memory
DIMI-O (optical input)	1971	1	Polyphonic synthesizer with a 32-step sequencer and a video interface
DIMIX (mixer and digital patch bay)	1971	1	Mixing console with a digitally controlled patch bay and video-camera connection
DIMI-U (universal)	1971–	0	Custom-compiled and modular music production system (none built)
DIMI-S (sexophone)	1972	2	Instrument controlled by the skin resistance of players
DIMI-P (programmable)	1972–	0	Custom-compiled and programmable studio system (none built)
DIMI-T (thinking; also known as Electroencephalophone or α/θ cyborg)	1973	1	Oscillator controlled by the EEG signal of the player
DIMI 6000	1973–75	2	Computer-controlled analog synthesizer
DIMI-H (harmonies)	2005	1	Software instrument based on Kurenniemi's mathematical theory of harmonies

I begin this historical overview at the University of Helsinki Electronic Music Studio and concentrate on the period when Kurenniemi was active at the university. However, it is not known exactly on what date he left in the early 1970s, and he continued to collaborate actively with composer Jukka Ruohomäki, who succeeded him at the University Studio. I have previously referred to the University Studio during its early years as Kurenniemi's studio (Ojanen 2013, 100). It was built and maintained by him, and occasionally it was even identified as such by Salmenhaara, among others, who entitled his article in *Nutida musik* published in 1964 "Kurenniemi och hans studio" (Engl. Kurenniemi and his studio).[89] How widely it was known as Kurenniemi's studio remains unknown. It did not have an official name, and it was variously referred to as the electronic music studio at the University of Helsinki, the Porthania studio, and the sound technical laboratory, for example. In this text I refer to the University of Helsinki Electronic Music Studio as the University Studio.

Having reviewed the history of the University Studio I move on to the custom-built instruments designed during 1967–69. Then I give a brief history of Digelius Electronics Finland, which was initially founded to manufacture

[89] See Salmenhaara (1964, 55).

Kurenniemi's instruments, and his series of DIMI instruments (1970–75) deserve a dedicated presentation. Here, I refer only to key events and works, some of which are analyzed in more detail in Chapter 7. Unfortunately, it is not possible to review every work and event realized with Kurenniemi's instruments in this study. For those interested in more thorough browsing, I have published a frequently updated data set[90] related to the appearances of the instruments, which includes all recognized events and works.

5.1 The University of Helsinki Electronic Music Studio

5.1.1 Setting the scene for the University Studio

Kurenniemi came to the world of music technology via a *technical hobby*, to borrow the concept from Haring (2007, 2–18). He first made contact with technology and electronic music before his involvement with the university and the world of science. As a teenager, he was an amateur radio operator (see Figures 8 and 9).[91] In fact, in his main interests and characteristics he closely resembled what Ensmenger (2010, 1–26) describes as *computer boys*.

One winter, during the school year 1959–60, Kurenniemi and his classmates Erkka Honkavaara, Erkki Salmenhaara, and Ilkka Oramo (b. 1940) built a small-scale electronic music facility in the organ balcony of their school, Helsingin Normaalilyseo[92] (see Figure 10). In a temporary setup, they used demonstration equipment from the physics class and a wire recorder to produce electronic music. As an amateur radio operator, Kurenniemi knew how to build and operate electronics. He recalled that the studio was dismantled after a few weeks when the school janitor noticed that they were drinking beer on the balcony. No recordings from these experiments survive.[93] (Kantokorpi 2002; Taanila 2002; see also Ruohomäki 2020; Kuljuntausta 2002; 2008) Later on, Kurenniemi gained technical expertise as a student and an assistant in the Department of Nuclear Physics at the University of Helsinki.

Salmenhaara and Oramo started as musicology students at the University of Helsinki in 1960, whereas Kurenniemi began his studies at the Department of Nuclear Physics and as an assistant at the Radio Astronomy station of the Department of Physics, after finishing his military service in 1961.[94] He

[90] See the Appearance of Erkki Kurenniemi's Electronic Musical Instruments: https://doi.org/10.5281/zenodo.842854

[91] See also Ojanen [forthcoming] Kurenniemi's biography in the National Biography of Finland in https://kansallisbiografia.fi/.

[92] *Uusi Suomi* (March 18, 1960, 18).

[93] *Hbl* (January 16, 1964, 11); Leino (1971, 35); Kurenniemi (2004) in an interview with Ojanen & Suominen.

[94] Erkki Kurenniemi in the register of Helsingin Normaalilyseo: 6136. Kurenniemi, Erkki Juhani. *Hämeenlinna 10 VII 1941; Vh Tauno Päiviö K ja Lea Marjatta Mikkola. — II:lle, yo 60. - LuK HY 67. - Vänr 61. (Engl. Born Hämeenlinna July 10, 1941; Parents: Tauno Päiviö K and Lea Marjatta

said in an *Hufvudstadsbladet* interview in 1964 that his interest lay in electronic music, and that his dream to build a studio of his own dated back to those school experiences. He was also aware that describing their early project as the electronic music studio may have been an overstatement.[95]

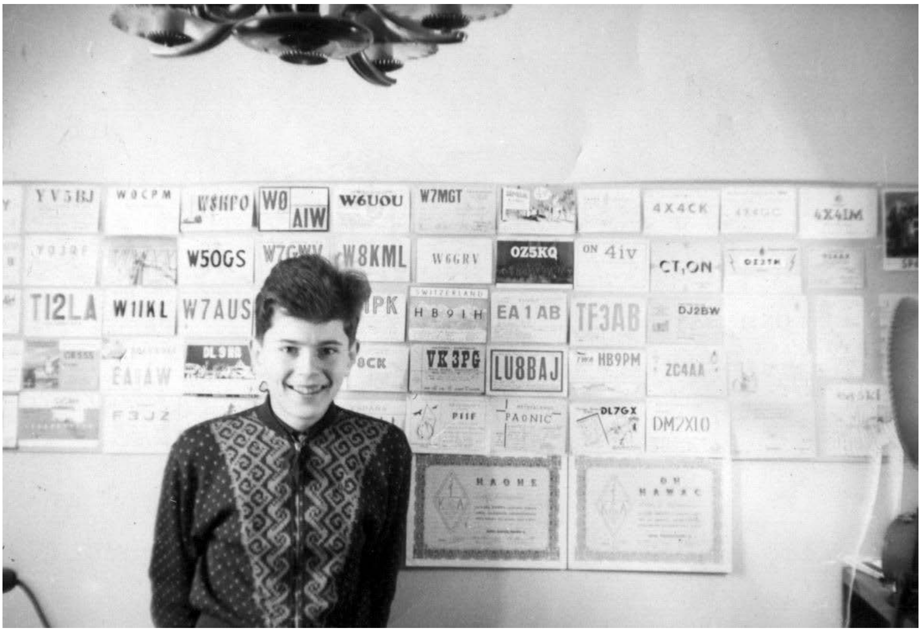

Figure 8. Young Kurenniemi practicing his technical hobby as an amateur radio operator; Kurenniemi with the QSL cards confirming the communication with other operators (photo: unknown / The Finnish National Gallery / EKA)

Mikkola; Matriculation 1960; B.Sc Univ. Helsinki 1967; Second lieutenant 1961) http://www.norssit.fi/semweb/#!/tiedot/http:~2F~2Fldf.fi~2Fnorssit~2Fnorssi_6136; Erkki Kurenniemi in the University of Helsinki Register of Students and in the University of Helsinki Register of Faculty of Science: Kurenniemi registered in the University of Helsinki as a student on Septempber 11, 1961. He completed his B.Sc in the Faculty of Science on June 6, 1967. The degree consisted of theoretical physics (cum laude approbatur), mathematics (cum laude approbatur) and practical philosophy (approbatur). Kurenniemi left the university books in the autumn semester of 1971. See also Kurenniemi's thesis in the Helsinki University Library collections, Kurenniemi (1972–1979?); see also Kurenniemi (1993a), in an interview with Ruohomäki.

95 *Hbl* (January 16, 1964, 11); Leino (1971, 35).

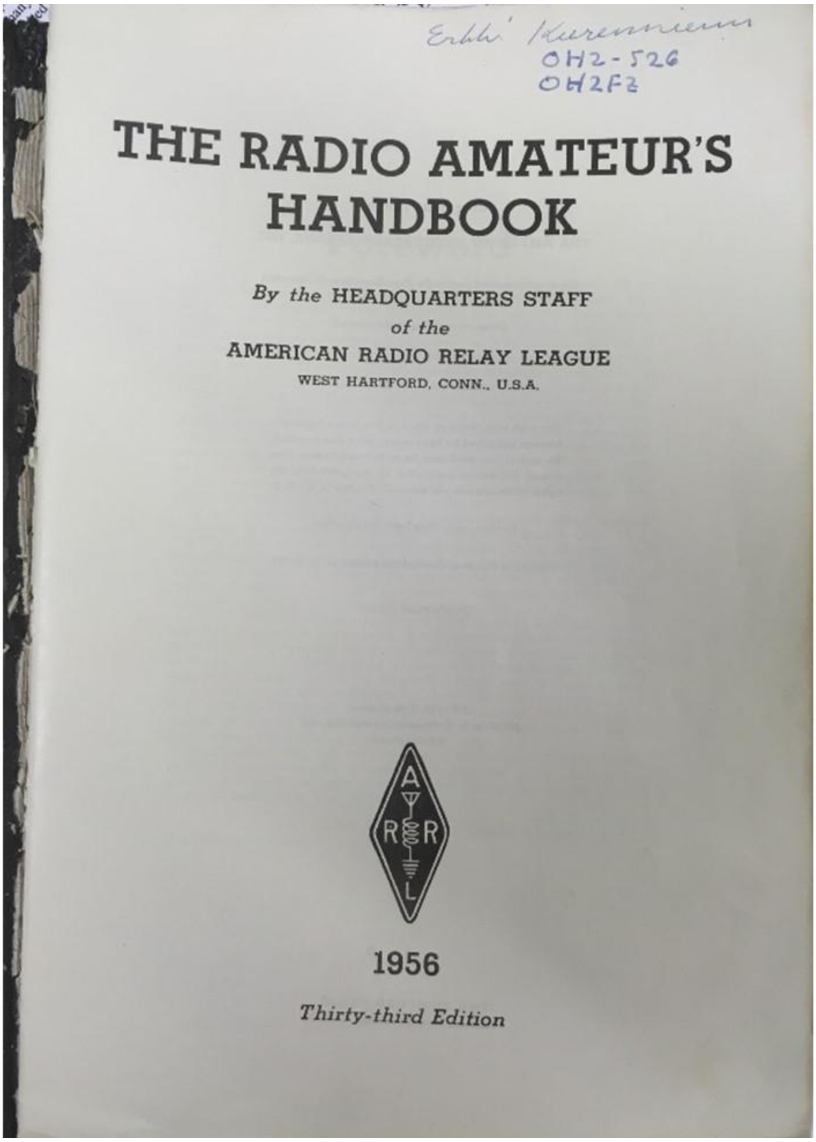

Figure 9. Kurenniemi's copy of *The Radio Amateur's Handbook* in the UHMRL archive, with his call signs OH2-526 and OH2F2; OH2 referring to the Province of Uusimaa and 526 referring to Taipalsaari municipality where the village Kurenniemi is located[96] (photo: Ojanen 2018)

[96] See the amateur radio operator call signs in Finland wiki: https://fi.wikipedia.org/wiki/Radioamat%C3%B6%C3%B6ritoiminnan_kutsumerkit_ja_yhteis%C3%B6t_Suomessa.

UUSI SUOMI

NUORISO NUORISO NUORISO

Kojeitten ääreen syventyneet pojat vasemmalta Erkka Honkavaara, Erkki Kurenniemi, Erkki Salmenhaara ja Ilkka Oramo.

Norssit elektronimusiikin parissa

Taiteen alati kytevään hiillokseen puhaltavat modernismin tuulet kaikilta tahoilta. Uusin suuntaus säveltaiteen alalla on tätä nykyä Ranskasta ja Saksasta kotoisin oleva ns. elektronimusiikki. Maallikkona tunkeuduin erääseen musiikin "vihaisten nuorten mies-

toiselle nauhalle ja samalla lisätään äänigeneraattorista uusia ääniä edellisen äänityksen päälle.

Selostusta havainnollistaakseen abiturientti Kurenniemi sääti vipua äänigeneraattorista niin suurille värähdysluvuille, että vaikka ääni katosi kuuluvista, laitteeseen kyt-

Figure 10. Kurenniemi and his classmates Erkka Honkavaara, Erkki Salmenhaara and Ilkka Oramo and their electronic music studio on the balcony of the school organ, featured in a youth column of *Uusi Suomi*, March 18, 1960[97] (photo: unknown / Uusi Suomi)

[97] See J.V. (1960, 18/*Uusi Suomi* March 18, 1960).

5.1.2 The foundation of the University Studio and the early years

The history of the University of Helsinki Electronic Music Studio started in 1961.[98] It was founded "through the initiative of the newly-appointed Professor of Musicology, Erik Tawaststjerna"[99], who wanted to follow current European trends and have an electronic music studio in his department.[100] During the first phase the studio housed three Telefunken M24 reel-to-reel tape recorders purchased by musicology student Seppo Heikinheimo, at the latest in January 1962.[101] Some time during the academic year of 1961–62, Tawaststjerna invited Kurenniemi to build up the studio as an unpaid voluntary assistant. Kurenniemi received the invitation from Tawaststjerna via Salmenhaara. Heikinheimo does not specifically mention Kurenniemi in his article on the founding of the studio in the *World of Music* magazine published in June 1962.[102] According to the studio inventory catalogue, however, it seems that Kurenniemi became involved in purchasing the studio equipment as early as in January 1962 – or at least he was consulted about acquisitions. He recalled in 2004 that the Telefunken M24 tape recorders had already been purchased when he started to build the studio, but he did not remember any collaboration with Heikinheimo during the first setup.[103]

In 1962, Kurenniemi equipped the University Studio with a spring reverb unit, a ring modulator, a filter, a noise generator, a four-channel mixer con-

[98] See Linkomies (1962, 69): "Laitokseen on perustettu ääniteknillinen laboratorio, joka on tietenkin vasta alkuasteellaan. Kojeisto käsittää mm. kolme Telefunken-pienoisstudiomagnetofonia, oskilloskoopin, useita äänigeneraattoreita, suodattimia ja ohjauspöytiä. Vaikean tilanpuutteen vuoksi laboratorio on sijoitettu esimiehen huoneeseen." (Engl. "A sound technical laboratory has been set up in the department, which is, of course, in its infancy. The equipment comprises three Telefunken miniature studio recorders, an oscilloscope, several sound generators, filters and mixer boards. Due to a severe lack of space, the laboratory is located in the supervisor's room.") Date when written or published unknown; most likely written in the fall of 1962.

[99] See Heikinheimo (1962, 56): "Studio of Electronic Music founded in Helsinki. Through the initiative of the newly-appointed Professor of Musicology at the University of Helsinki, Erik Tawaststjerna, a Studio of Electronic Music has been founded. University students in music research and composition will be allowed to use the studio. Up to now only the technicians of the Finnish Radio had the possibility of experimenting with the electronic equipment." Date when written or published unknown; most likely written in or before June 1962; published no earlier than late June, this issue of *World of Music* (Vol. 4, Number 3, June 1962) includes reviews of the Sibelius week held "during the first week of June." (Heikinheimo 1962, 55).

[100] According to Kurenniemi (1993a; in an interview with Ruohomäki on October 28, 1993), Tawaststjerna thought that the Department of Musicology should have an electronic music studio.

[101] See the UHMRL Inventory catalogue: p. 18, inventoried by ES in January 1962: "Telefunken pienoisstudiomagnetofoni M24 K (täysraita), arvo 290.000; Telefunken pienoisstudiomagnetofoni M24 KL (puoliraita), arvo 273.000; Sama, arvo 273.000" (Engl. "Telefunken miniature studio recorder M24 KL (full track), value 290,000; Telefunken miniature studio recorder M24 KL (half track), value 273,000; Same, value 273,000"); UHMRL Inventory catalogue, p 19, inventoried by E.S. in February 1962: "Oskilloskoopin rakennussarja Heathkit, arvo 51.840." (Engl. "Oscilloscope building kit Heatkit, value 51,840.")

[102] Heikinheimo (1962, 56).

[103] Kurenniemi (2004) in an interview with Ojanen & Suominen; see also Ruohomäki (2020, EH22).

sole, and a few oscillators built from an assembly kit. By September 1, at the latest, he had built some of the equipment including the mixing desk and the Heathkit oscilloscope (purchased in February 1962; see Figure 11). He completed the setup in 1963 with a Studer C37 professional tape recorder.[104]

Kurenniemi's first assignment with the first studio setup (1962–1964) was to produce electronic sounds for Ylioppilasteatteri's theater play *Tintagilesin kuolema*.[105] The production plan was introduced to the press on October 9, 1962[106] and the play was premiered on January 29, 1963.[107] In 2013, recalling the play and its music, Henrik Otto Donner mentioned, for example, that no live pianist was used and that the piano music was played from the tape.[108] The theater performance or the rehearsals were recorded. Among his other recordings, Donner used fragments[109] from this audio recording in the soundtrack of Eino Ruutsalo's film *Kaksi kanaa* (1963), completing the first version of the soundtrack in the University Studio before early April 1963. The film was premiered at the Annecy International Animated Film Festival in June 1963 (Home [forthcoming]; see also Kuljuntausta 2002, 413). In addition to working on *Kaksi kanaa*, Donner prepared the tape music parts for his live works *Ideogramme I and II* (1963) in the University Studio (see Ojanen 2014a, 2–3). The second version of *Ideogramme I* with the background tape was premiered on February 4, 1963 at the Ung Nordisk Musik concert in Helsinki, and *Ideogramme II* in Taidehalli on April 7, 1963. Donner left for a trip to Europe after the Taidehalli concert.

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[104] See Salmenhaara (1964, 55); see also UHMRL Inventory catalogue, p 38; Inventoried by E.K. on October 1, 1967: "Studer C37 No. 353, arvo 9543."; see also Kivinen (1963, 65): "Laitoksen ääniteknilliseen laboratorioon on hankittu Studer-merkkinen magnetofoni sekä muuta pienempää kojeistoa." (Engl. "The Studer tape recorder and other smaller equipment were purchased for the Department's sound technical laboratory.")

[105] Originally a play for marionettes by Maurice Maeterlinck (1894); French *La Mort de Tintagiles*; Engl. *The Death of Tintagiles*.

[106] *HS* (October 9, 1962); *Uusi Suomi* (October 10, 1962); see also Kuljuntausta (2002, 387–388; 2008, 203–205).

[107] According to the minutes of a meeting of the executive committee of Ylioppilasteatteri held on January 15, 1963, Jyri Schreck introduced the premieres for the spring term, listing both *Tintagilesin kuolema* and *Carlos ja kynttilät* to be premiered on January 29, 1963 (TeaMA1487: Cb:2). According to the minutes of a committee of meeting held on February 6, 1963, Kurenniemi was paid FIM70 (nmk 70; approx. €150 in 2019) for *Tintagilesin kuolema* (TeaMA1487: Cb:2). According to the Ylioppilasteatteri's annual report of 1963, *Tintagilesin kuolema* was translated into Finnish by Markku Raudas, staging design by Juhana Blomstedt, costumes by Anja Blomstedt, electronic music by Erkki Kurenniemi. The play was performed 17 times. (TeaMA1487: Db) *Tintagilesin kuolema* was performed in Tampereen Työväen Teatteri and at Jyväskylän kulttuuripäivät (Ylioppilasteatteri executive committee minutes, May 4, 1963 / TeaMA1487: Cb:2). Kuljuntausta (2002, 387–388; 2008, 203–205) mistakenly claims that the play was performed as early as in November and December 1962.

[108] Donner (2013) in an interview with Home & Ojanen.

[109] According to Donner (2013: 1:14:10–1:17:45), Pirkko Peltonen's lines "Igram, minä kuolen ellet sinä ---" used in the film *Kaksi kanaa* were from the recording of the theater performance.

Figure 11. Professor Erik Tawaststjerna in his office with the first studio equipment on September 1, 1962 In the seemingly framed photo session, Tawaststjerna is controlling the Telefunken M24 tape recorder with his left hand and the horizontal position of the image of the Heathkit Laboratory Oscilloscope O-12 with his right hand. It remains unclear whether the oscilloscope is connected or switched on or not. Underneath, and left from, the oscilloscope there is custom-built studio equipment – probably mixer and amplifier units assembled by Kurenniemi. Another Telefunken M24 is placed behind Tawaststjerna. Kurenniemi's[110] retrospective description of the interiors of department's office and the location of the equipment corresponds with the photograph. (photo: Pertti Jenytin / Lehtikuva[111] September 1, 1962)

The two first standalone tape music works from the studio were Kurenniemi's *On-Off* (1963) and Erkki Salmenhaara's *White Label* (1963), both of which premiered at the Jyväskylän Kesä festival on July 11, 1963. Even though a few individual works such as *Tintagilesin kuolema*, *Kaksi kanaa*, and versions of *Ideogramme* had been performed publicly during the first

[110] Kurenniemi (2004) in an interview with Ojanen & Suominen.

[111] Picture in the Lehtikuva archive, ID: 6667509; Date created: 19620901; Creator: Pertti Jenytin; Subject/Caption: "Professori Erik Tawaststjerna magnetofonien ja Tekniikan ääressä 1. syyskuuta 1962." (Engl. "Professor Erik Tawaststjerna with the recoders and technology on September 1, 1962."). The photograph was previously published in *Finnish Music Quarterly* in 1987, and in Wikimedia Commons in 2017.

half of 1963, the electronic music concert in Jyväskylän Kesä was considered the first official public appearance of the studio. Reviewing Jyväskylän Kesä in *Ylioppilaslehti* dated August 30, 1963, Ilpo Saunio refers to the unknown host of the concert. He introduced it as the first public collective appearance of the University Studio, which had already established its specific sound and had received a lot of attention in music circles.[112]

After Kurenniemi had built the first studio setup in the departmental office the studio moved to the cellar of the Porthania building. As Kurenniemi recalled in 2004, the move was due to the disturbance it caused when located on the office floor of the building. The meteorologists next door did not appreciate the studio experiments as music. Kurenniemi associated the critical comments and the move to the cellar with his recording session of *On-Off*, which could have happened at the end of 1962.[113] The container of the *On-Off* master tape[114] does not include any date markings. Donner claimed that he produced the background tape for *Ideogramme I*[115] and the soundtrack for *Kaksi kanaa*[116] in the cellar studio.[117] However, according to the university's annual report for the academic year 1963–64, the studio moved to the cellar in the fall of 1963.[118] The exact dates of the move, and of Kurenniemi's *On-Off* session remain unknown. (Ruohomäki 2020, EH22/4–5; EH23/3–4)

In August 1963, Kurenniemi, Donner, Salmenhaara, Kaj Chydenius, and Raija Mattila produced a tape collage *Äänikirje Jan Barkille* (1963; Engl. Sound Letter to Jan Bark) as a tribute to Swedish composer Jan Bark, who had given a composition course in Helsinki during August 1963[119] (Kuljuntausta 2008, 208). Parts of tape collage were recorded in various locations. The project was directed by Chydenius, according to whose instructions Kurenniemi spliced the final work.

The collaboration between Ylioppilasteatteri and the University Studio continued in early 1964 when Kurenniemi realized an electronic soundscape for Yukio Mishimas's play *Hanjo* – the first Japanese Noh theater play to be performed in Finland.[120] Ere Kokkonen directed a version of the play for Mainos-TV (Finland's commercial television channel), which was aired on

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[112] Saunio (1963, 4).

[113] Kurenniemi (2004) in an interview with Ojanen & Suominen.

[114] See Ojanen, Mikko. (2020). *The Photo Set of the Master Tape of Erkki Kurenniemi's On-Off* (1963) (Version 20200108_01). Zenodo. http://doi.org/10.5281/zenodo.3601403.

[115] Premiered on February 4, 1963.

[116] Completed before Donner's trip in early April 1963.

[117] Donner (1994) in an interview with Ruohomäki.

[118] See Kivinen (1964, 69): "Laitoksen äänitekniikan laboratorio on ollut jatkuvasti rakenteilla ja sitä varten on hankittu erilaatuista pienempää kojeistoa, tarvikkeita sekä ääninauhoja. Syyskaudella ääniteknillinen kojeisto siirrettiin Porthanian kellarissa sitä varten varattuun huonetilaan." (Engl. "The department's sound technical laboratory has been continually under construction, and smaller-sized equipment, accessories and audio tapes have been acquired. It was moved to a designated room in the Porthania cellar during the fall.")

[119] Salmenhaara (1964, 55).

[120] Reijonen-Oibopuu (1964, 16/*HS* February 2, 1964).

March 22, 1964.[121] The original recording of the televised version has been destroyed – neither MTV nor the National Audiovisual Institute have any information about Kokkonen's version.[122] Two years later *Hanjo* was performed at Kansallisteatteri (Engl. The Finnish National Theater) with Kurenniemi's electronic soundscape.[123] All the versions included Kurenniemi's electronic sound design and music reproduced from tape during the performance. Whether or not he revised the sound work for different performances is not known.

Donner, together with Ken Dewey and Terry Riley as well as Swedish composers Jan Bark and Folke Rabe, were key people involved in bringing happenings to Finland during 1963 and 1964 (see Donner's connections to happenings in Ruohomäki 2013). Together with Ralf Forsström and Pertti Lumirae, Donner organized *Limppiece* (1964) in the Ateneum Art Museum on April 4, 1964, in which they diffused the sound and held separate events to occupy the entire museum space. Members of the audience were guided through the space by means of a map showing the locations and schedules of the events (see Figure 12[124]).

Kurenniemi produced an hour-long tape to be played as a soundscape in the museum space during the happening (see the text ÄÄNINAUHA; Engl. The sound tape as described on the bottom row throughout the score). According to Mauri Antero Numminen (b. 1940), Kurenniemi's electronic soundscape for *Limppiece* was based on the idea that sound alters so slowly that the audience cannot perceive changes without leaving the space for a few minutes (Numminen in Ruohomäki 2013, 11[125]).

On the same day as the *Limppiece* happening, Numminen performed in the academic singing contest with Laulukone[126] (Engl. Singing Machine) accompanied by the background tape he produced in the University Studio. The background tape exists, but the tapes for *Tintagilesin kuolema*, *Hanjo* and *Limppiece* have not survived, or their location is unknown. No audio recordings that can be identified as having been associated with these events have been discovered. Thus, further analysis of the works is impossible. I return to other key works from the early years of the University Studio in Chapter 7.1.

[121] *HS* (March 22, 1964, 15).
[122] The movie entry in the International Movie Database (IMDb) reveals that the recording was in black and white, and the duration was 50 minutes (see IMDb entry: https://www.imdb.com/title/tt1454005/).
[123] *HS* (July 2, 1966, 9); Arpiainen (1966a, 13); see also Arpiainen (1966b, 16) for a review of *Hanjo* in *HS*, September 22, 1966.
[124] A guiding map of the event is published in Anttonen (1995).
[125] See also Numminen (2018) in an interview with Ojanen.
[126] For a closer description of Numminen and Laulukone, see Chapter 5.2.1.

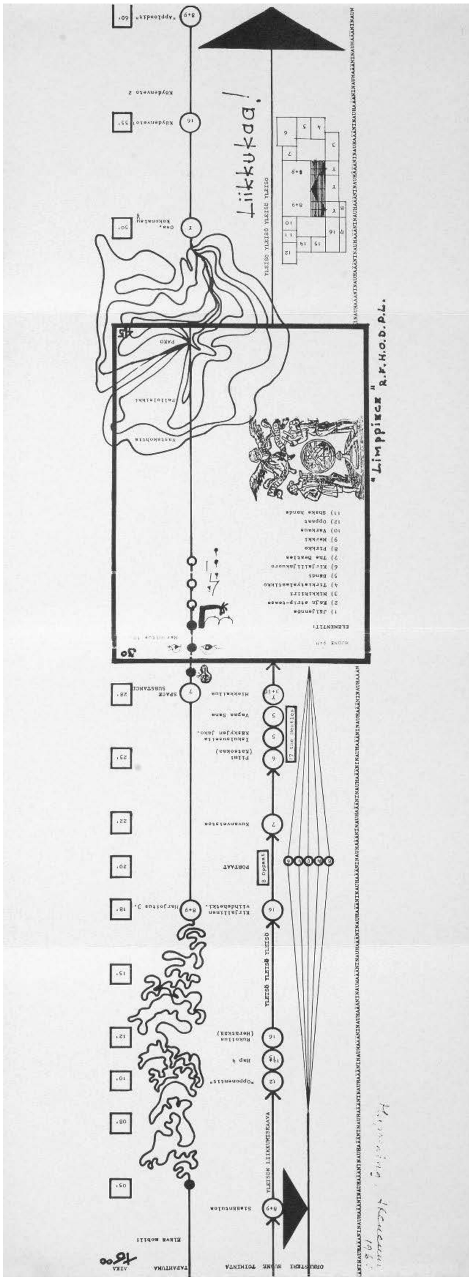

Figure 12. A map of the *Limppiece* (1964) happening in the Ateneum Art Museum, organized by Henrik Otto Donner, Ralf Forsström and Pertti Lumirae on April 4, 1964. The floor plan of the museum with numbered rooms is pictured in the down right corner of the score. The timeline is running from left to right with corresponding circled room numbers indicating where and when separate events are taking place. The score instructs the audience to move around in the museum and follow the guiding map of the events (photo: the Finnish National Gallery collections / Erkki Kurenniemi archive)

5.1.3 The Integrated Synthesizer: the heart of the University Studio

Having built his first studio setup, Kurenniemi started to execute the extensive design plans he had begun to draft in 1962[127]. He attended the electronic music festival Stockholms Elektroniska Festspel[128] in Sweden from March 16–18, 1963, in the company of Donner, Heikinheimo, Chydenius and Reijo Jyrkiäinen.[129] Kurenniemi presented his plans for the forthcoming studio at the seminar for electronic music that was part of the festival. He believed that they differed from contemporary mainstream studio designs even then.[130] (Ruohomäki 2020, EH22/7; Hultberg 1994, 178–179)

Kurenniemi envisioned the University Studio as a modular and integrated facility with automated music-production possibilities. Even though he never visited any of the leading studios in Europe, such as RTF in Paris and WDR in Cologne, he was aware of the technology and layout of contemporary setups.[131] He did not wish to follow current trends, relying mainly on voltage-controlled analogue circuits and tape manipulation. Among other influences, his experience as computer programmer at the Department of Nuclear Physics convinced him that "the future would be digital", as he reminisced in 2004.[132]

Groth's (2014, 115–119) description reveals that the overarching initial plans directing Kurenniemi's designs were very similar to those used in Stockholm when the Elektronmusikstudion EMS was in the planning stage. For example, Norwegian-Swedish composer Knut Wiggen, who also presented his ideas at the seminar, criticized the solutions and the current state of the leading Central European studios, and suggested basing EMS on different premises – as a hybrid of analog and digital electronic and automated processes. According to Wiggen (1972, 127), who led the EMS in 1964–1975, the "clear signal to use an advanced technical solution" and not "to copy any existing studio" came from Karl-Birger Blomdahl, who was the Head of Swe-

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[127] Salmenhaara (1964) refers here to the years 1962 and 1963. The text seems to have been written in early 1964; Jan Bark's composition course, which Salmenhaara reviews, was held in August 1963. See also *Hbl* (January 16, 1964, 11).

[128] See Hultberg (1994, 178–179) for the program of Stockholms Elektroniska Festspel, March 16-18, 1963; see also Groth (2014, 117–119) for the discussion during the research seminar. In the following years, Swedish composers Jan Bark and Folke Rabe performed in concerts, organized seminars and composed works in Finland. Folke Rabe attended Jyväskylän Kesä in July 1963, Jan Bark organized a seminar in Helsinki in August 1963, and during the next year composed two works in the University Studio *Elmus* (1964) and *Sverige* (1964) (Davies 1968, 147). They both attended *Sabotaasikonsertti* (Engl. Sabotage Concert) organized in Ritarihuone, Helsinki on October 18, 1963.

[129] *Dagens Nyheter* of April 4, 1963 reports on five young Finnish composers and music critics, but the text does not explicitly list Kurenniemi, Donner, Chydenius, Heikinheimo and Jyrkiäinen as attendees: their names are mentioned later in the text.

[130] Chydenius (1963, 6) / *Hbl* April 2, 1963; *DN* (April 4, 1963, 19); Salmenhaara (1964); *Hbl* (January 16, 1964).

[131] *Hbl* (January 16, 1964, 11).

[132] Kurenniemi (2004) in an interview with Ojanen & Suominen.

dish Radio's Music Department. The tape-manipulation techniques were already considered outdated in the early 1960s and the planning was focused on automated and computerized implementation.

Kurenniemi started to build a system in which sound production and control signals were based on digital logic. Even though the implementation of digital logic modules in music systems was a new development, Kurenniemi was not utterly alone in his endeavor: computer and digital control signals were guiding EMS designs, for example, and Seppo Mustonen was experimenting with the Elliott 803 B computer in Kaapelitehdas in Helsinki. Kurenniemi frequently visited Stockholm and EMS during the 1960s and 1970s, and apparently even consulted EMS about their plans.[133] (Wiggen 1972; see also Groth 2014, 115–116)

The computer metaphor that drove Kurenniemi's designs reflects his interest in algorithmic composition and in building a machine that was capable of producing preprogrammed music automatically.[134] As he recalled in 1993, he was more interested in building an automated machine than in the music production.[135] One of his main sources of inspiration was the RCA's digitally controlled synthesizer designed by Harry F. Olson and Herbert Belar in the early 1950s.[136] Olson and Belar were convinced that music could be generated mathematically by means of a computer. Their design ideas were based on Claude E. Shannon's mathematical theory of communication (Baer 2011).

Kurenniemi was also inspired by Max Matthews's experiments with computer-generated music in the Bell Laboratories.[137] Matthews (1963) wrote a popularizing article about music by numbers in *Science* (1963), and the computer music of Matthews, James Tenney, and Newman Guttman was presented at Stockholms Elektroniska Festspel. Greek-French composer Iannis Xenakis also attended the festival, presented several of his own works and hosted panel discussions in Stockholm (Hultberg 1994, 178–179). The world's leading advances in computer and digital music were at Kurenniemi's disposal from very early on in his career.

The first manifestation of Kurenniemi's automated music machine was the three-piece studio system. His goal was to build a modular system into which the entire studio could be integrated and that could control all the equipment, including the tape recorders. The system was eventually named

[133] Nilsson (2019) in an interview with Ojanen. Interestingly, Kurenniemi's ideas of sound generation and rhythm were very similar to those expressed by Leon Theremin and Joseph Schillinger some three decades earlier. They include theories of rhythm and methods of electronic sound generation, which are based on mathematics and subharmonics. At the time, the ideas were implemented in electronic instruments such as the Trautonium and the Rhytmicon. The recent design by Moog Music, the Subharmonicon (2020), is based on the ideas of Theremin and Schillinger, combined. It is not known how well Kurenniemi was aware of these methods in the 1960s. For more information see Glinsky (2000, 131–136), Smirnov (2013, 43–77), Patteson (2016, passim.).

[134] *Hbl* (January 16, 1964, 11).

[135] Kurenniemi (1993a) in an interview with Ruohomäki.

[136] Kurenniemi (2004) in an interview with Ojanen & Suominen.

[137] Kurenniemi (2004, 34) in an autobiographical article in *Framework*.

the Integrated Synthesizer.[138] The name is anachronistic, however, in that the system did not have a proper name initially, and it is not known when it first appeared. The system was referred to as the Sähkö-ääni-kone (Engl. electric sound machine; see Home 2013) in 1968, whereas in the early 1970s Kurenniemi called it System-1 in his curriculum vitae.[139] (Ruohomäki 2020, EH22; Ojanen and Suominen 2005, 18–20; Suominen 2013, 133–135; Lassfolk et al. 2015, 262) According to Pinch & Trocco (2002a, 67), wondering what to call a new instrument was a typical problem in the 1960s. US synthesizer designers Robert Moog and Donald Buchla, for example, hesitated to use the word synthesizer: Moog used it for the first time in print in 1966.

Kurenniemi's first system consisted of the tone generator unit, the mixer unit, and the filter unit (see Figure 13). The tone generator and mixer units are still in the University Studio's collection, but the filter unit was lost or dismantled during the 1960s. Only the tone generator and mixer units are recognizable in various photographs, and the missing filter unit has not been identified among the documentary evidence. Kurenniemi recalled that he probably dismantled the filter unit because it was already a conventional design by 1960s standards.[140]

Compared with the RCA synthesizer, among the advantages of Kurenniemi's instrument were its portability[141] due to the compact size – the system weighs only 20 kilos and covers an area of one square meter – and its capability to produce rhythm patterns, melodies, and harmonies in real time. The RCA Mark II synthesizer measured over two by six meters and weighed about three tons. Furthermore, the RCA system was incapable of real-time sound production, being programmed with punched paper tape (Baer 2011; Holmes 2012; 176–190). On the other hand, it could be (pre)programmed more precisely than Kurenniemi's system, the parameter input of which was approximate.

Kurenniemi said in an interview conducted during 1993 that he did not have a design plan for the instrument, and that he built it module by module in a trial-and-error process.[142] He spotted interesting designs in the contemporary literature and tried them out. On account of this practice, the Integrated Synthesizer was under constant development and was never fully completed. What remains of it bears less resemblance to a finished music technological product than to a workbench for prototype testing that strongly resembles the current DIY modular synthesizer format or Eurorack projects, for example. Apparently, for the same reason, the instrument was poorly documented. Without a strict deadline, such as with the commissioned in-

[138] I use the name Integrated Synthesizer in this study when referring to the instrument.

[139] See Kurenniemi's CV in FNG/EKA, 1971.

[140] Kurenniemi (2004) in an interview with Ojanen & Suominen.

[141] Portability was also one of the key features of Buchla's Music Systems (see Buchla Associates 1966).

[142] Kurenniemi (1993a) in an interview with Ruohomäki.

struments he later designed, Kurenniemi did not have any reason to complete the project.[143]

Figure 13. Kurenniemi with his first music system – later called the Integrated Synthesizer – in an unknown location in Helsinki, March 23, 1965. The location could be the University Studio in its second setup in the cellar of the Porthania building. However, M. A. Numminen, who worked in the studio at the time, does not recognize the room.[144] A six-channel mixer unit (in a sideways-upward position its bottom faced to the camera) in front of Kurenniemi. On the right, behind Kurenniemi, the tone generator unit (its rear panel faced to the camera) and behind his right shoulder a meter bridge of some sort (later dismantled or vanished). The meter bridge and mixer unit are waiting to be installed into the custom build table which corner is partially visible on the left – in the interview in 2004, Kurenniemi described a table like the one in the picture.[145] (photo: Holger Ekholm / Lehtikuva[146] March 23, 1965)

143 Kurenniemi (1993a and b) in interviews with Ruohomäki.
144 Numminen (2018) in an interview with Ojanen.
145 Kurenniemi (2004) in an interview with Ojanen & Suominen.
146 Picture in the Lehtikuva archive, ID: 1316442; Date created: 19650323; Subject/Caption: “19650323 HELSINKI: Suomalaisen elektronisen musiikin varhainen vaikuttaja säveltäjä-keksijä

In the second phase (1964–1968) the University Studio was built around the Integrated Synthesizer. As Ruutsalo recalled in his retrospective memoires (2000, 88[147] in Home 2013, 17), Kurenniemi had the first version of the tone generator unit in a functional condition in the fall of 1964. During the evening following the completion of this first version he recorded sound material for the experimental film *Hyppy* (1965). Swedish composer Leo Nilsson[148] also recorded sound material with "Kurenniemi's music machine" for his work *Skorpionen*[149] (1964).

The dates of these recording sessions are unknown. Ruutsalo's *Hyppy* was premiered at the Westdeutsche Kurzfilmtage in Oberhausen on February 21–27, 1965 (Elonet 2013; see also Home [forthcoming][150]), while Nilsson realized *Skorpionen* for the exhibition to honor Pablo Picasso on his 84th birthday on October 25, 1965. *Skorpionen* was released on a 7" sound record by Konstsalongen Samlaren (Engl. The Samlaren Art Salon; Samlaren translates into English as collector). The owner of the gallery, Agnes Widlund, sent the sound recording to Radio Andorra, where the work was aired in October 1965.[151]

Erkki Kurenniemi." (Engl. "Early influencer of Finnish electronic music, composer-inventor Erkki Kurenniemi.")

[147] Ruutsalo describes how they produced the sound material in the Vironkatu studio, but the department did not move to Vironkatu until two-and-a-half years later in early 1967. It is worth mentioning that that Ruutsalo wrote his memoires decades afterwards and therefore on the detailed level they would need critical revision. Some of the electronic material included in the background tape for two works by M.A. Numminen (*Ontogim* and *Oigu-S*) may have been produced with an earlier version of the generator unit or with a similar construction during the spring of 1964.

[148] Nilsson (2019) in an interview with Ojanen. Leo Nilsson wrote his surname with one s in his early works and record sleeves. Here I use the version with a double-s.

[149] Skorpionen has a subheading "Musiken til hyllningsutställningen 'Picasso i går och i dag'" (Engl. Music for the tribute exhibition "Picasso yesterday and today"). See Nilsson's work released by Samlaren (Private pressing by Samlaren, 1964) in Discogs database: https://www.discogs.com/Leo-Nilson-Skorpionen-Copa-De-Poma/release/11323683#images/31900490). Nilsson has made the work openly available in his Soundcloud account, see https://soundcloud.com/user-745910767. The title refers to Picasso's star sign (see Nilsson 2019) – Picasso was born on October 25, 1881. See also the sleeve notes of Lundsten and Nilsson (1966) Elektronmusikstudion Dokumentation 1 (Sveriges Radio, LPD 1, 1966) in Discogs database: https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Elektronmusikstudion-Dokumentation-1/release/938156.

[150] For *Hyppy* (1965) details in Elonet, see: https://www.elonet.fi/fi/elokuva/129895. See also Home ([forthcoming]): "XI. Westdeutsche Kurzfilmtage Oberhausen vom 21. bis 27. Februar 1965, Diplom, Der Film Hyppy (Prod. Eino Ruutsalo, Regie Eino Ruutsalo) wurde aus einem Angebot von 935 Kurzfilmen aus 45 Nationen für das Wettbewerbsprogramm der Westdeutschen Kurzfilmtage ausgewählt" as in attendance diploma in the Eino Ruutsalo Archive.

[151] *DN* (October 24, 1965, 23); Mangs (1965, 15); DN (November 20, 1965, 41); *DN* (February 10, 1966, 10); see also Nilsson (2019) in an interview with Ojanen.

Figure 14. The Integrated Synthesizer: tone generator unit under eager inspection by Ralph Lundsten (in the middle, over the instrument), Leo Nilsson (on the right) and two unrecognized participants (in the background) of the algorithmic music seminar organized by Fylkingen as a part of Jyväskylän Kesä festival program in Kilistiikka building of the University of Jyväskylä, July 1965. Photo originally published in *Helsingin Sanomat* on July 8, 1965 accompanying the festival review by Seppo Heikinheimo[152] (photo: unknown / Lehtikuva[153])

152 Heikinheimo (1965).

153 Picture in the Lehtikuva archive, ID: 2038894; Created; [Anonymous] Date Created: 19650707; Subject/Caption (as in *HS* review): "19650707 JYVÄSKYLÄ: Erkki Kureniemen [sic!] rakentama "musiikkitietokone" on ollut kiinnostuneen tarkkailun kohteena vanhassa kilistriikka[sic!]-rakennuksessa Jyväskylän korkeakoulualueella, Algoritmimusiikki kuuluu osana Jyväskylän Kesään." (Engl. "The 'music computer' built by Erkki Kureniemi [sic!] has been under an eager observation in the old kilistriikka [sic!] building in the Jyväskylä university area, Algorithmic music is part of Jyväskylän Kesä.") Photo originally published in Seppo Heikinheimo's review of Jyväskylän Kesä in *Helsingin Sanomat*, July 8, 1965. Heikinheimo (1965, 11) does not mention the algorithmic music seminar in his review. See also Kivinen (1965, 73): "Laitoksen äänitekniikan laboratorio on ollut jatkuvasti rakenteilla ja sitä varten on hankittu erilaatuista kojeistoa. Syntetisaattori on kesällä 1965 valmistumisvaiheessa." (Engl. "The sound technical laboratory of the Department is constantly under construction and various equipment has been purchased to meet its needs. The synthesizer will be completed in the summer of 1965.") See also Ruohomäki (2020, EH22/7): "Algoritmisen musiikin seminaari pidettiin Jyväskylän kesän v. -65 ohjelman mukaan 4.–9. 7. Kureniemen esitelmän otsikkona oli 'About definitions, programs, machines and all that'. Muita esitel-

Kurenniemi presented the tone generator unit on July 7, 1965 at the algorithmic music seminar organized jointly by the University Studio and Fylkingen – New Music and Intermedia Art, a Swedish association for experimental music and art, as part of the Jyväskylän Kesä festival. Nilsson attended the seminar with his close collaborator composer Ralph Lundsten (see Figure 14; see also Städje 2012). According to Lundsten, he and Nilsson visited the University Studio in Porthania on December 17, 1965, where they recorded the sound material[154] they used in the work realized for the exhibition *Hej Stad* (1966; Engl. *Hi, City!*). The exhibition was organized by the Swedish Museum of Architecture, initially at Moderna Museet in Stockholm in April 1966, and then in Messuhalli (Engl. Exhibition Hall) in Helsinki in May 1966. The electronic exhibit was the first four-channel work to be produced in the Swedish Radio Studio, and the sound was diffused around the exhibition space to accompany 2,800 slides depicting the modern urban environment. The work presented in the exhibition was released as a sound recording, *Elektronmusikstudion Dokumentation 1* (Sveriges Radio, LPD 1, 1966) entitled *Aloha Arita*[155] (1965–66), named after the two movie theaters located next to the University Studio in Helsinki at the time. According to several documents,[156] the sound material for the work was first recorded in

möitsijöitä olivat mm. Carl Lesche, joka puhui tietokonemusiikin estetiikasta ja Knut Wiggen, jonka aiheena oli 'Kompositionssystemet Wiggen 1'. Seminaari oli järjestetty yhteistyössä Ruotsin nykymusiikkiseuran Fylkingenin kanssa." (Engl. "According to the festival program the algorithmic music seminar was held in Jyväskylä in the summer of -65, July 4- 9. Kurenniemi's presentation was entitled 'About Definitions, Programs, Machines and All That'. Other lecturers included Carl Lesche, who spoke about the aesthetics of computer music, and Knut Wiggen, on 'Kompositionssystemet Wiggen 1'. The seminar was organized in cooperation with the Swedish Contemporary Music Society Fylkingen.")

[154] Lundsten (2018) in an interview with Ojanen.

[155] Nilsson has uploaded *Aloha Arita* to his Soundcloud account under the name *Alarm*, which was the title of the Stockholm architecture exhibition in 1965, which preceded *Hej Stad*.

[156] See the sleeve notes on their first LP record *Elektronmusikstudion Dokumentation 1* (Sveriges Radio – LPD 1, 1966): "Hösten 1965 tog planerarna av Alarm-utställningen ånyo kontakt med Sveriges Radios elektronmusikstudio för att fortsätta samarbetet. Denna gång gällde det musik till invä/ågningutställningen för Sveriges Arkitekturmuseum på Moderna Museet i Stockholm, april 1966. Elektronmusikstudion lokala apparatekniska situation var nu något gynnsammare, då delar av den beställda apparaturen hade börjat anlända och studion hade fått sig tilldelad lokaliteter på Kungsgatan 8. Men fortfarande hade studion små möjligheter att producera det musikaliska råmaterialet. Tonsättarna Ralph Lundsten och Leo Nilson, som åter kontaktades, löste problemet genom att ta kontakt med fysikern och tonsättaren Erkki Kurenniemi i Helsingfors och från hans musikmaskin spela in kompositionens råmaterial. Detta material bearbetades sedan i SRs elektronmusikstudio. Denna komposition döptes till 'Aloha Arita' och den är en ren elektronisk komposition, dvs. det finns inga inspelade klanger i form av röster, instrumentala klanger eller vardagsljud med." (Engl. "In the autumn of 1965, planners of the Alarm exhibition contacted the Swedish Radio Music Studio again to continue the collaboration. This time it was music for the inaugural exhibition of the Swedish Museum of Architecture at Moderna Museet in Stockholm, in April 1966. The technical situation at the electronic music studio was now somewhat more favorable: equipment that had been ordered began to arrive, and the studio was allocated premises at Kungsgatan 8. However, the studio had little opportunity to produce the raw musical material. Composers Ralph Lundsten and Leo Nilson were again contacted, and solved the problem by con-

the University Studio on Kurenniemi's instrument, and then finalized in the Swedish Radio Studio in Stockholm.[157]

Previously, only *Aloha Arita* has been presented as an example of Lundsten and Nilsson's work based on the sound material recorded on the Integrated Synthesizer. Closer analysis of their works – both collaborative and individual – indicates that they used sounds from the instrument more widely than previously thought. Lundsten also used sounds from the Integrated Synthesizer on the soundtrack of his film *EMS nro 1* (1966). Städje (2012; 2017) claims that the instrument in question is the Andromatic sequence-synthesizer, which is impossible given that Kurenniemi built it two years after Lundsten released the film (see Chapter 5.2.2). The synthesized and sequenced sounds in *EMS nro 1* strongly resemble the sounds in *Aloha Arita*. In both works, the Integrated Synthesizer is only one sound source among others. If one listens closely one can hear that sequences in works such as *Skorpionen* (1964) and *Skulpturmusik* (1966) by Nilsson, the first part of their collaborative three-piece *Jo, Nä, Oj* (1966), and *Tellus* (1968) closely resemble the sonic characters of the Integrated Synthesizer.

The Department of Musicology and the studio moved from the Porthania building to a new location in Vironkatu in early 1967 (see Figure 15).[158] In-

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tacting physicist and composer Erkki Kurenniemi in Helsinki and recording the raw material on his music machine. This material was then processed in SR's electronic music studio. The composition was entitled 'Aloha Arita' and it is a purely electronic, in other words there are no recorded sounds in the form of voices, instruments or everyday noise.")

See also Lundsten's (2006, 52; 2014, 56) memoires, and comments from both in their individual interviews (Städje 2012; Lundsten 2018 in an interview with Ojanen; Nilsson 2019 in an interview with Ojanen).

[157] See Heimolan talo pictures with the names *Aloha* and *Arita* in Finna by Hakli (1959; 1969); see also *DN* (March 24, 1966, 15); Zweigberck (1966, 4); *HS* (May 4, 1966, 16); Maunula (1966, 22 [*HS* May 15, 1966, 22]) Lundsten (2006, 52; 2014, 56); Lundsten (2018) an interview with Ojanen.

[158] See Tawaststjerna's application for funds dated January 26, 1967: "Historiallis-kielitieteelliselle Osastolle / Anon kunnioittavasti, että Musiikkitieteen laitokselle myönnettäisiin vuodeksi 1968 elektronisen studion perushankintoihin mk 8.000:-. / Noin puolet tästä summasta tulisi käytettäväksi laitoksella itse konstruoitavan digitaali-analogia-konvertterin osien hankkimiseen. Tämän kojeen avulla voidaan muodostaa suurella tarkkuudella mielivaltaisia signaaleja, ja sitä voidaan käyttää myös tutkimustyöhön. Toinen suurehko hankintakohde olisi monikanavanauhuri. Näiden laitteiden lisäksi studion kehittäminen edellyttää eräiden pienempien laitteiden hankkimista. / Elektronisen studion siirryttyä nyt musiikkitieteen laitoksen uusiin tiloihin (Vironkatu 1) sen kehittämismahdollisuudet ja sen käyttö elektronisen musiikin realisoimiseen ja tutkimustyöhön ovat kokonaan uudella pohjalla. Mainittakoon, että studiossa realisoidaan parhaillaan Montrealin maailmannäyttelyyn tilattua elektronista sävellystä. / Helsingissä 26.1.1967 (Erik Tawaststjerna)"

(Engl. "To the Historical-Linguistic Department / I respectfully request that the Department of Musicology be granted FIM 8,000 for the basic procurement of an electronic studio for 1968. / About half of this amount would be used to purchase parts for the digital-to-analog converter constructed in the department. This instrument can generate high-resolution arbitrary signals and it could also be used for research purposes. Another major acquisition would be a multi-channel recorder. In addition to this equipment, the studio needs to purchase some smaller pieces. / Now that the electronic studio has moved to the new premises of the Department of Musicology (Vironkatu 1), its development potential and its use in research and in the realization of electronic music stalled in the new premises, Kurenniemi and Kari Hakala used the Integrated Synthesizer as a sound source for the two-piece work *Saharan uni* (1967), which was the first stereophonic electronic work produced in Finland. Kurenniemi and Hakala recorded the sound material in the University Studio in Vironkatu, but they mixed the final work with the four-tracker in the Yle sound-control room in Kulttuuritalo (Helsinki Hall of Culture).[159] On October 27, 1967, Kurenniemi was interviewed for the short documentary film about Markku Nurminen's computer-generated tango *Kesän muistatko sen*, which was composed on a computer according to an algorithm based on analyses of Toivo Kärki's tangos. Kurenniemi commented on the results, on the current situation, and on the future of computer music in general.

Saharan uni was premiered on February 9, 1968 during the *Sähköshokki-ilta* (Engl. Electro Shock Evening) event at the Amos Anderson Art Museum in Helsinki, at which the Integrated Synthesizer made its last known public appearance (see Figure 16).[160] The event was part of Ruutsalo's *Valo ja liike* (Engl. Light and Motion) exhibition at the museum on February 7–14, 1968. Ruutsalo describes his starting point for the exhibition in a press release about the event: "We have to set pictures in motion whatever it takes. For there is no life without motion. In stillness lurks death." (Ruutsalo in Home 2013, 17.) This was realized in the exhibition with moving lights, pictures and films projected on the walls, and light kinetic works that were constantly transforming. Visitors were allowed to touch the sculptures. A tape music collage *22'20"* consisting mainly of sounds edited from the soundtracks of the experimental films was played repeatedly in the exhibition space. (Home 2013, 17)

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is on a whole new level. It should be noted that an electronic composition commissioned for the Montreal World Expo is currently being realized in the studio. / Helsinki, January 26, 1967 (Erik Tawaststjerna)"). FIM 8,000 in 1967 was equivalent to about EUR12,500 in 2019.

See also Kivinen (1967, 91): "Laitos muutti kl:lla uusiin tiloihin, Vironkatu 1:een. Tilat käsittävät kuunteluhuoneen, pienen lukusalin ja seminaarisalin, ääniteknillisen laboratorion, kansliahuoneen sekä esimiehen ja assistentin huoneet. - - - Ääniteknillistä studiota on jatkuvasti suunniteltu, täydennetty ja rakennettu."

(Engl. "The department moved to new premises at Vironkatu 1 in the Spring. The facilities include a listening room, a small reading room and a seminar room, a sound-technology laboratory, a clerk's room and a room for a manager and an assistant'. - - - The sound-technology studio is constantly being designed and perfected.")

[159] Hakala (2013) in an interview with Lassfolk & Ojanen.

[160] Sähköshokki-ilta programme, Pictures at Lehtikuva's archive, Pictures at the Amos Anderson museum archive, sound recording from the rehearsals on February 8, 1968.

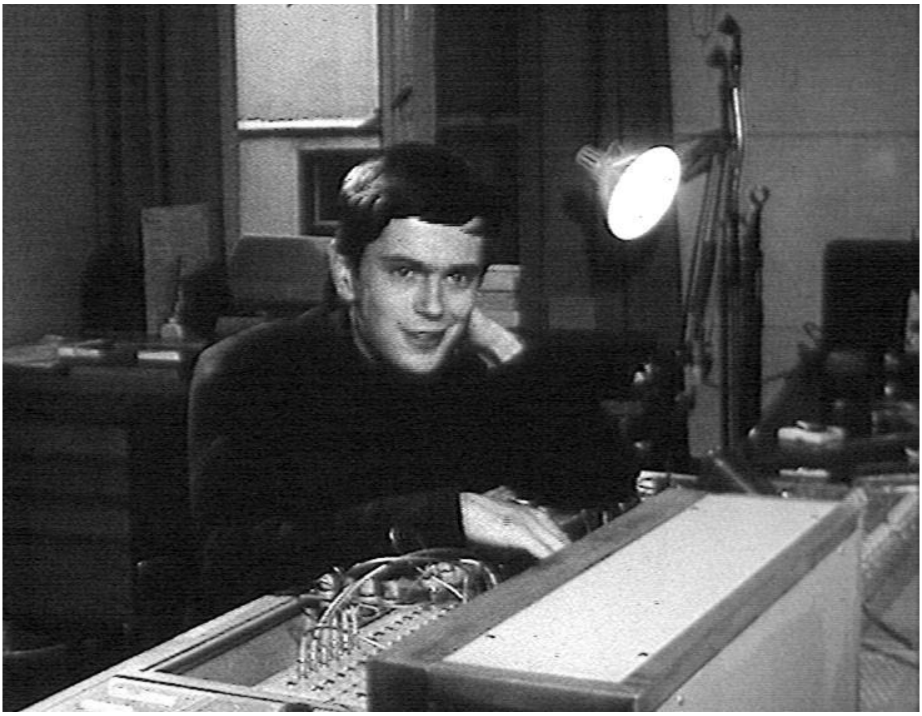

Figure 15. Kurenniemi and a glimpse of the Integrated Synthesizer in the documentary film *Kahdeksan tahtia tietokoneelle* (Engl. Eight bars for a computer). Kurenniemi's interview was recorded in the University Studio on Vironkatu in the fall of 1967. (photo: a screen shot of the documentary film / Yle)[161]

Ruutsalo also organized concerts as part of the exhibition. The first one, *Sähköshokki-ilta* (Electric Shock Evening) on February 9, 1968, consisted of Johann Sebastian Bach's Inventions Nos. 3 and 4 on a pipe organ played from the tape, the premier of Kurenniemi and Hakala's electronic tape music work *Saharan Uni*, an improvisation with the Integrated Synthesizer featuring Kurenniemi and Donner, accompanied by Donner's younger brother Philip on an amplified zither, the machine poems, and Donner's electronic guitar improvisation *Execethis*.

[161] Documentary film *Kahdeksan tahtia tietokoneelle* in Yle's archive; Name of the program: Kahdeksan tahtia tietokoneelle (Engl. Eight bars for a computer). Media ID: MEDIA_2012_00467326; Program ID: PROG_2009_00123373; First aired on October 27, 1967. Director: Aki Oura.

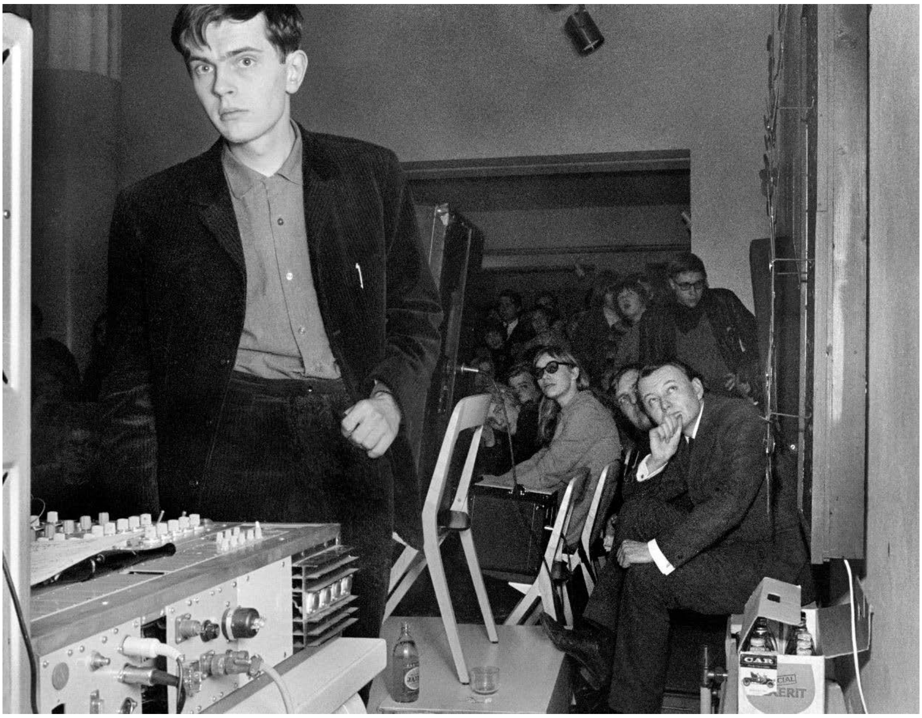

Figure 16. Kurenniemi with the Integrated Synthesizer at the Amos Anderson Art Museum's event *Sähköshokki-ilta* (Engl. Electric Shock Evening) on February 9, 1968 The event was a part of Eino Ruutsalo *Valo ja liike* (Engl. Light and movement) exhibition in the museum during February 7 to 14, 1968 (photo: Mikko Oksanen / Lehtikuva, February 9, 1968[162])

The second studio setup and the Integrated Synthesizer remained in use until late 1968 or early 1969, the exact date on which the studio was re-arranged and the Integrated Synthesizer retired is unknown. The instrument served as the sound source on the soundtrack of Risto Jarva's short commercial film *Tietokoneet palvelevat* (1968; Engl. Computers Serve), which was commissioned by Postisäästöpankki (Engl. Postal Savings Bank) and completed on September 9, 1968.[163]

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[162] Picture in the Lehtikuva archive, ID: 22215978; Date Created: 19680209; Subject/Caption: "Sähköshokki-ilta, monitaiteellinen happening Amos Anderssonin [sic!] taidemuseossa 9. helmikuuta 1968. Henrik Otto Donner tekee musiikkia, Claes Andersson lausuu runojaan. Eino Ruutsalon kineettistä taidetta on myös esillä. Edessä vasemmalla Erkki Kurenniemi sekä hänen suunnittelemansa sähkö-ääni-kone (integroitu syntesoija). Taustalla yleisön joukossa Kalevi Seilonen ja Claes Andersson." (Engl. "Electro shock night, inter-artistic happening at the Amos Anderson Art Museum on February 9, 1968. Henrik Otto Donner makes music, Claes Andersson recites his poems. The kinetic art of Eino Ruutsalo is also on display. On the left is Erkki Kurenniemi and the electric sound machine (integrated synthesizer). Kalevi Seilonen and Claes Andersson in the audience.")

[163] See KAVI database: https://elavamuisti.fi/aikajana/tietokoneet-palvelevat; See Elonet database: https://www.elonet.fi/fi/elokuva/601470

Kurenniemi and the third phase of the University Studio feature in the unpublished documentary film about the musical activities of composer Henrik Otto Donner, produced as a documentary training project for the Yle education office in early 1969[164] (see Figure 17). The Integrated Synthesizer does not appear in the documentary. The only sound source present is the Sähkökvartetti (Engl. Electric quartet; see Chapter 5.2.1), which was used in works realized in the University Studio during 1969, such as in the soundtrack of Jarva's short commercial film *Pakasteet II* (1969; Engl. Frozen Foods II), commissioned by Paulig Ltd.[165] The other equipment presented in the documentary includes the Studer C37 tape recorder, the studio equipment rack,[166] and some unidentified devices. Composer Jukka Ruohomäki[167], who started to work at the University Studio in 1969, recalls that the Integrated Synthesizer was there, but he does not remember it being used.[168]

Kurenniemi took part in the International Convention of Experimental Centres of Electronic Music at Teatro Comunale in Florence, Italy on June 9–14 in 1968, where he presented his plans to build a music terminal. According to the plans, the terminal computers would allow a remote connection to a main frame located at the university. On payment of a small fee, people could contact the university main frame computer and produce music over the network connection. This would have required digital to analog (A/D) converters, which Kurenniemi was designing at the time[169] (Zaffiri 2007).

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164 A documentary project produced by a group consisting of Aaltonen, Kajander, Lampila, Marttila, Saar, Vehniäinen (kuvaus/äänitys = shooting/recording: Kaivanto, Ketola, Mähönen) at Yle's education office; Title: Otto Donner / 15 min. (Materiaalinauha = material tape). Document in Yle's archive; Media ID: MEDIA_2015_00923242; Program ID: PROG_2009_0035191; completed on February 24, 1969.

165 See KAVI database: https://elavamuisti.fi/aikajana/pakasteet-ii; See Elonet database: https://www.elonet.fi//fi/elokuva/640415

166 The rack is the same as in the Sähköshokki-ilta pictures from February 9, 1968. (See e.g. Amos Anderson Art Museum archive; Figures 112; see also the photograph of M.A. Numminen in the Vironkatu studio; Figure 24.)

167 *MTL Juuso* is mentioned for the first time in Kurenniemi's daily planner, Sunday February 16, 1969 (Kurenniemi daily planners in the UHMRL archive).

168 Ruohomäki (2004) in an interview with Ojanen & Suominen; Ruohomäki (2018) in an interview with Ojanen.

169 See Kivinen (1968, 100–101): "Ääniteknisen studion suunnittelu- ja rakennustyötä on jatkettu koko lukuvuoden ajan. Silmällä pitäen omia ja Fonetiikan laitoksen tarpeita laboratoriossa on kehitetty studiovahvistinsarja, josta koottu ensimmäinen sekoitusvahvistinyksikkö on valmistunut toukokuussa. Studion yhden päätavoitteen, musiikkiterminaalin suunnitelmat on saatu keskeisiltä osiltaan valmiiksi, ja sen rakennustyö on aloitettu toukokuussa. - - - Volontääriassisstentti Erkki Kurenniemi osallistui laitoksen edustajana kesäkuussa 1968 Firenzen Teatro Comunalen järjestämään elektronimusiikin kongressiin pitäen siellä esitelmän laitoksessa kehitteillä olevasta musiikkiterminaalista." (Engl. "The design and construction of the sound studio have continued throughout the academic year. For the needs of both Departments, the Department of Musicology and the Department of Phonetics, a studio amplifier kit has been developed in the laboratory, the first mixing amplifier unit of which was completed in May. One of the studio's main goals, the music terminal, has largely been completed, and construction work began in May. - - - Voluntary assistant Erkki Kurenniemi attended the Congress of Electronic Music organized by Teatro Comunale in

Figure 17. The University Studio presented in the unreleased documentary about Henrik Otto Donner (in a black shirt and mustache on the left-hand side). Filmed in the early 1969. Kurenniemi (on the right) is pointing to an unidentified equipment. The Studer C37 is partially visible in the bottom-right corner.[170] (photo: a screen shot of the unreleased documentary: Otto Donner/15 min, Materiaalinauha, Yle archive)

According to funding applications related to the University Studio[171] and Eniro Zaffiri's conference notes (2007), Kurenniemi's terminal computer, main frame and converter development were active for a couple of years, but not a single unit was built.[172] The idea re-emerged later in his DIMI instruments in the 1970s. Kurenniemi[173] envisioned that composers would be able to communicate with their studios directly – and eventually that technology would even be capable of reading their thoughts directly. Theses utopian visions nevertheless remained unattainable.

Florence in June 1968, giving a presentation on the music terminal being developed at the Department.")

170 Document in Yle's archive; Media ID: MEDIA_2015_00923242; Program ID: PROG_2009_0035191; completed on February 24, 1969.

171 Tawaststjerna (1970; 1971); the Department of Musicology annual funding applications in the UHMRL archive.

172 Kivinen (1969, 89): "Äänitekniseen studioon on hankittu kaksi nauhuria sekä musiikkiterminaaliin kuuluvan musiikkikone 2:n laitteita. Studiossa on jatkettu musiikkiterminaalin kehittämistä tietokoneliitäntää silmällä pitäen." (Engl. "Two tape recorders have been purchased for the sound technical studio, as well as equipment for the second music machine, which is part of the music terminal. The studio has continued to develop a music terminal with a computer interface in mind.") On the plans to build an analog-digital-analog converter see also the Department of Musicology annual funding applications.

173 Kurenniemi (1971a).

5.1.4 Towards conventional tape music and recording studios

The gap between technological idealism and reality did not hinder the active use of the studio throughout the 1960s and 1970s. There was not yet the technology to realize Kurenniemi's far-reaching utopian visions of advanced automated algorithmic music production, therefore most of the works produced in the University Studio were based on tape manipulation or sound recording and processing. From the early 1970s it was equipped with Kurenniemi's DIMI synthesizer-sequencers the DIMI-A and the DIMI-O (see Chapter 5.3), and in December 1970 Kurenniemi purchased the EMS VCS-3 (Putney) synthesizer for the studio from British synthesizer manufacturer Peter Zinovieff. Thereafter the Electric Quartet, the DIMIs (mainly DIMI-A), and the Putney were the main electronic sound sources in the studio. By 1972, in the fourth phase of its history, all the instruments were connected to the DIMIX digital mixer and patch bay unit.[174]

Gradually, the University Studio became known as the place in which to produce electronic sounds and to compose electronic works, and many electronic music works and electronic sounds for popular music recordings were realized there over the years. The tape music works from the studio were frequently performed in local concerts such as the regular Yle concert series in Vanha Ylioppilastalo (1969; 1970; 1971) also known as Electrononstops[175], and the frequent tape music concerts in the Porthania Music Hall and in Yle's Liisankatu Studio. Ruohomäki started teaching electroacoustic music in the studio during the academic year 1972–73. The participants of the first course included rock guitarist Hasse Walli, composers Otto Romanowski, Tuomo Teirilä, and Eero Hämeenniemi, among others.

One of the first works completed using the new sound sources of the studio – the Putney and the second version of Kurenniemi's DIMI synthesizer, the DIMI-O video organ – was the sound recording *Muusa ja Ruusa* (1971), which consists of songs for children based on the work of Finnish poet Kirsi Kunnas and composed by saxophonist and composer Eero Koivistoinen (b. 1946).[176] The album was released as a literary sound recording by WSOY (Werner Söderström OY) but remained unknown at the time.[177] The Univer-

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[174] The DIMIX was acquired from Digelius Electronics Finland in 1971. See the DIMIX specifications; UHMRL Inventory catalogue, p. 12 inventoried by JR on March 31, 1974: "DIMIX sekoituspöytä; arvo 16 200" (Engl. "DIMIX mixer; value 16 200"); see also Juva (1972, 96–97): "Äänitekniseen studioon on hankittu DIMIX-ristiinkytkentäpöytä, johon kaikki studion laitteet on kytketty, sekä JBL-Lansing -kaiutinjärjestelmä. Lisäksi on hankittu nauhureita, vahvistimia ja muita studiolaitteita." (Engl. "The DIMIX mixer to which all studio equipment is connected, and a JBL-Lansing speaker system has been purchased for the sound technical studio. Recorders, amplifiers and other studio equipment have also been purchased.")

[175] It is noteworthy that Fylkingen in Stockholm also arranged events entitled Electrononstop – see also Saunio (1963, 4) referring to the "plan for an electronic music nonstop concert hall".

[176] Koivistoinen, Eero 1971. *Muusa ja Ruusa*, LP, WSOY WS 8; see: https://www.discogs.com/Eero-Koivistoinen-Muusa-Ja-Ruusa/release/2450473

[177] See the record sleeve notes by Henriksson (2016); Tarkka (1971, 22/*HS* review on November 28, 1971).

sity Studio's synthesizers appear on three tracks of the record – the Putney on *Sammakkokeitto* (Engl. Frog Soup) and *Herra Pii Poo* (Engl. Mister Pii Poo), and the DIMI-O on *Sammakkojen ulosmarssi* (Engl. The Walkout of the Frogs). Other early sound recordings of popular music consisting of electronic sounds produced in Finland and associated with the University Studio include Pekka Streng's (1972) *Kesämaa* (Engl. Summerland) with the Putney on *Mimosaneito* and *Roope Hattu*, Hector's (1973) *Herra Mirandos* (Engl. Mister Mirandos) with the Putney on several tracks.

Kurenniemi concentrated on his company Digelius Electronics Finland in the early 1970s. However, even when he started withdrawing from the university,[178] he maintained close collaboration with his successor in the studio, composer Jukka Ruohomäki, and the other composers and artists in the field of electroacoustic music. Kurenniemi's company was located in Katajanokka – a district in Helsinki that is close to the University Studio. He documented some of his casual visits to the studio in his audio diaries.[179]

Under Ruohomäki's leadership the emphasis of the University Studio shifted from instrument design to electroacoustic music composition among teaching. Although Kurenniemi built and maintained the studio in different physical spaces (see Table 4), as a physical space it was irrelevant to him. In the fall of 1975 it was relocated to new facilities on the courtyard-side of the Vironkatu building. The difference between Kurenniemi's studio in the 1960s and Ruohomäki's in the 1970s is striking: Kurenniemi's instruments remained in use, but Ruohomäki re-arranged the overall layout to resemble the traditional tape music studio more closely (see Figures 18–21).

The history of the studio from the late 1960s intertwines with Kurenniemi's custom-built instruments commissioned by artists and composers (see Chapter 5.2) and the history of his company Digelius Electronics Finland (see Chapter 5.3). I return to the history of the University Studio later in connection with these themes.

[178] According to Juva (1973, 150), Kurenniemi resigned from his post at the Department of Nuclear Physics on March 15, 1973

[179] According to his audio diary on October 8, 1972 (C4060; R-4086 '72-10-08 Dimi demo TRD dimensio + "Sunday 12:31") Kurenniemi is driving from the Vironkatu Studio where he met Ruohomäki who was maintaining the DIMIX. Kurenniemi picked up the DIMI-O video-controlled synthesizer on his way to the Dimensio exhibition in Tampere. The DIMIX was also expanded in 1972; see DIMIX purchase documents in the UHMRL archive (ID: HMA DEF Musiikkitieteen studio DIMIX 0611_001; ID: HMA Musiikkitieteen studio DEF DIMIX 1972 0612_001).

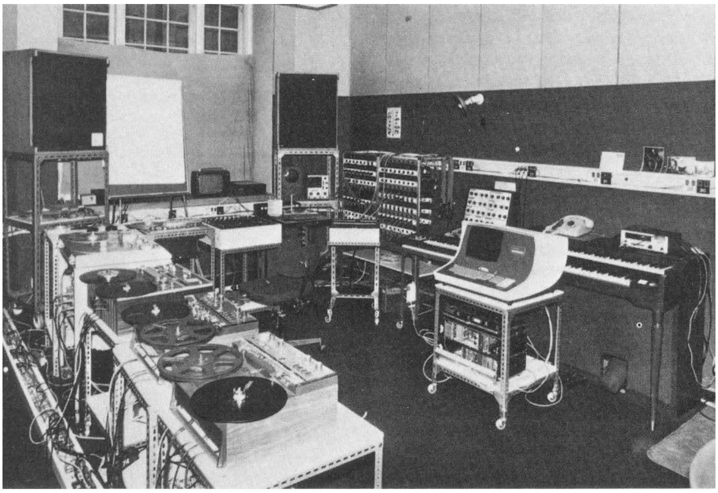
Table 4. The University Studio locations and setups during the time when Kurenniemi was active there, from the early 1960s to the mid-70s. I have chosen the periods for studio setups according to points when there was a major change in the core technology such as the main sound source, however, the studio was naturally under constant development and different technological setups overlapped.

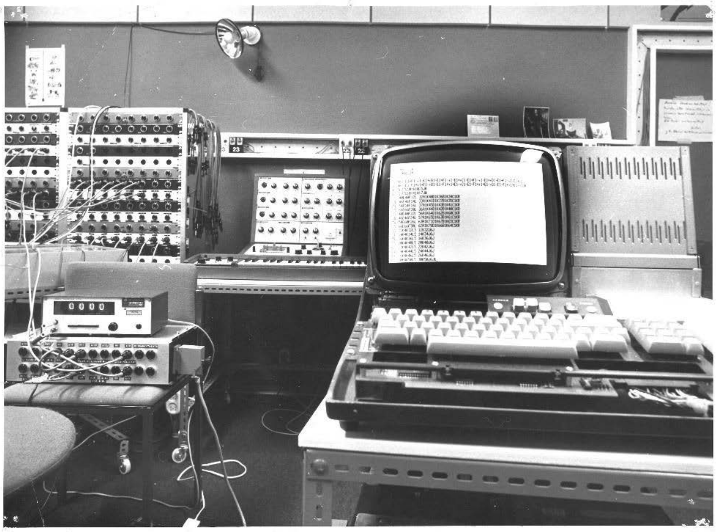
Studio location	Years	Studio setup	Years	Maintained by
Porthania, 6th floor	1961–	The 1st pre-synthesizer setup	1962– summer 1964	(Heikinheimo) Kurenniemi
Porthania cellar	1963–	The 2nd setup; Integrated Synthesizer	fall 1964– late 1968	Kurenniemi
Vironkatu 1, the 1st studio facility, 1st floor	January 1967–	Same as above		Kurenniemi
Vironkatu 1, the 2nd studio facility, 1st floor corner room	1969/70(?)–	The 3rd setup; Sähkökvartetti (occasionally)	1969– August 1970[180]	Kurenniemi, Ruohomäki
Vironkatu 1, the 3rd studio facility, 4th floor	1971 –	The 4th setup: VCS-3, DIMI-A, DIMI-O[181]	August 1970– 1975	Kurenniemi, Ruohomäki
Vironkatu 1, the 4th studio facility, the courtyard room	1975 autumn–	The 5th setup Ruohomäki's studio	1975–	Ruohomäki

[180] Kivinen (1970, 82): "Äänitekniseen studioon on hankittu nauhureita, vahvistimia ja muita studiotarvikkeita. Studion äänipöydän piirustukset ovat valmiina ja sen rakentaminen on aloitettu." (Engl. "Recorders, amplifiers and other studio equipment have been purchased for the sound technical studio. The studio sound board drawings are ready and construction has begun.")

[181] Kivinen (1971, 82): "Laitoksessa LuK Erkki Kurenniemen johdolla harjoitetun tutkimustyön tuloksena on syntynyt digitaalisyntetisaattori Dimi. Äänitekniseen studioon on hankittu myös elektroninen musiikkistudio VCS-3, jossa on dynaamisesti porrastettu koskettimisto. Lisäksi on hankittu nauhureita, vahvistimia ja muita studiotarvikkeita." (Engl. "As a result of research conducted by Erkki Kurenniemi BSc., the digital synthesizer Dimi has been born. The VCS-3 electronic music studio with a dynamically graded keyboard has also been purchased for the sound technical studio, together with recorders, amplifiers and other studio equipment.")

Figures 18 and 19. The University Studio in 1973 maintained by composer Jukka Ruohomäki and Kurenniemi. The upper photo: Kurenniemi's DIMI-A synthesizer (1970) on the lower table on the left. From there on clock-wise the Putney keyboard and the Putney, Studer C37 and A62 tape recorders, the digital patch bay and mixer DIMIX (1971), the EMT turntable and a cassette recorder. The lower photo taken from another angle, from behind the DIMI-A. The red TV monitor of the digital patch bay and mixer DIMIX seen between the JBL speakers. (photos: unknown / The Finnish National Gallery / Erkki Kurenniemi archive)





Figures 20 and 21. The University Studio in 1976 or 1977 maintained by Ruohomäki. In the upper photo equipment clockwise from the left: three Revox A77 tape recorders, Studer C37 tape recorder, Studer A62 tape recorder, mixing console, the DIMIX mixer and digital patch bay (in front of the right speaker) and its small TV monitor between the JBL speakers on the back wall, the oscilloscopes underneath the right channel JBL speaker, the left one is the Heathkit O12 was purchased in 1962 and seen in the previous photo (see Figure 11), the DIMI-A synthesizer (in front of the patch bay), the Putney and its keyboard behind the DIMI 6000 synthesizer (in front of the electronic organ). In the lower photo DIMI-6000 ADDS terminal cover open due to its heating problems (See also Figure 83 in Chapter 6.2.5).[182] (photos: unknown / *Otavan iso musiikkitietosanakirja*[183])

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182 Rautee & Hoikkala (2017) in an interview with Ojanen.

183 See Ala-Könni et al. (1977, 147).

5.2 Customized designs commissioned by artists and composers

During 1967–1969, Kurenniemi designed the customized instruments Sähkökvartetti (1968), Andromatic (1968) and DICO (1969) at the request of Mauri Antero Numminen, Ralph Lundsten and Leo Nilsson, and Osmo Lindeman, respectively. This section is based mainly on contemporary documents such as photographs and newspaper articles, as well as oral history, in other words memory sources. The origins of Sähkökvartetti and Andromatic in particular are somewhat contradictory in terms of detail, there being very little documentary evidence concerning the initial design and planning of these instruments. There are considerably more contemporary documents related to Lindeman's DICO, including four interviews[184] as well as Lindeman's scrapbook, pictures and two encyclopedia articles. However, even these contain conflicting information. In the following sub-sections, I review the unresolved details as part of the narrative.

5.2.1 From avant-garde to underground with M.A. Numminen and Sähkökvartetti: the instrument and the group

In 1960, soon after leaving school, Mauri Antero Numminen moved to Helsinki from Somero to study sociology at the University of Helsinki. He was a jazz drummer, and from early on he was interested in avant-garde art forms. When he moved to Helsinki, he soon acquainted himself with the avant-garde art scene. Numminen met Kurenniemi for the first time at a culture-radical gathering of some 30–40 people organized by Claes Andersson in 1963 at his home in Tammisaari. Both Kurenniemi and Numminen had a background in amateur radio electronics and were able to talk about equipment on the component level: they immediately got along.[185] (Suominen 2013, 135–139)

Around the turn of 1964, Numminen enrolled for the academic singing contest to be held on April 4.[186] He made use of the University Studio in early 1964 to prepare for the contest, in which he wanted to perform avant-garde electronic music. He planned to perform two pieces, *Ontogim*[187] and *Oigu-S* (1964), for which he needed equipment to process his singing. With Kurenniemi's assistance, he and his childhood friend Kullervo Aura built an elec-

[184] See Koskimies (1972), Paalanen (1974), Sermilä (1975), and Santalahti (1980)
[185] Numminen (1999, 283–290); Numminen (2018) in an interview with Ojanen.
[186] *Uusi Suomi* (April 5, 1964, 20); *Viikkosanomat* (April 10, 1964, 47); *Expressen* (October 24, 1966, 5).
[187] Numminen published a graphic notation and a text related to *Ontogim* in his *Kauneimmat runot* poem collection in 1970 (see Numminen 1970).

tronic sound-processing unit called Laulukone (Engl. Singing Machine).[188] The device consisted of signal paths that effectively distorted Numminen's voice (see Ruohomäki 2020, EH37/4–5). Numminen recalls that Aura attended the performance and plugged the cords in a patch matrix of the device according to his prescribed time-based score. As accompaniment and using University Studio equipment, Numminen produced a background tape[189] that included concrete and electronic sounds. For the performance, he placed a chess clock on the top of the Telefunken M24 tape recorder, which was borrowed from the University Studio and on which they followed the time. (see Figures 22 and 23) Numminen used Laulukone only a couple of times. The instrument was short-lived and Kurenniemi soon dismantled it, using the parts in other projects.[190]

Numminen returned to electronic music in 1966 and started to design a new instrument[191] (Suominen 2013, 136). Numminen raised FIM 5,000 in funding in the form of a personal bank loan. The loan was guaranteed by the office secretary of the Communist Party of Finland for the purpose of building Sähkökvartetti (1968, Electric quartet[192]) – an electronic instrument collectively played by four musicians. Numminen recalls that the idea for such an instrument was based on his Underground rock orchestra that started performing in late 1967. He wanted an electronic version of his rock quartet.[193] According to a short interview in *Stump* youth magazine in June 1968, Numminen formed the Underground rock orchestra while waiting for his electric quartet.[194] His experiences with Laulukone three years earlier also played a role in the development of Sähkökvartetti (Lindfors & Salo 1988, 86–87).

Numminen recalls that Kurenniemi designed the instrument while Aura built it.[195] However, details such as their respective roles in the building process remain unclear. According to Numminen they completed the instrument in the Porthania cellar studio, but more contemporary documents are needed to establish the timeline. The planning may well have started in Porthania in 1966, but the University Studio moved into new premises in January 1967

[188] The University Studio provided the parts – but whether or not Kurenniemi helped to design the system remains unknown. The device was completed by Aura together with Numminen in the Porthania cellar studio.

[189] The background tape for *Oigu-S* has been released on a retrospective compilation album *More Arctic Hysteria / Son Of Arctic Hysteria: The Later Years Of Early Finnish Avant-Garde* (LXCD 647) by Love Records in 2005. See: https://www.discogs.com/Various-More-Arctic-Hysteria-Son-Of-Arctic-Hysteria-The-Later-Years-Of-Early-Finnish-Avant-Garde/release/600283

[190] Numminen (2018) in an interview with Ojanen; see also Numminen (1999, passim).

[191] In an interview with Gronow (1966, 47), published in *Iskelmä* magazine in September 1966, Numminen describes a collective instrument that resembles his forthcoming electric quartet.

[192] Before its completion, Sähkökvartetti was called the Melody machine; see TV (1968, 9).

[193] In an interview with Suominen, Numminen (2006 in Suominen 2013, 136) recalled that the idea was based on a jazz quartet.

[194] *Stump* (1968a, 5).

[195] Numminen (2018) in an interview with Ojanen, see also Numminen (2020, 111).

and it is unlikely that there was any further activity in Porthania after the move.[196]

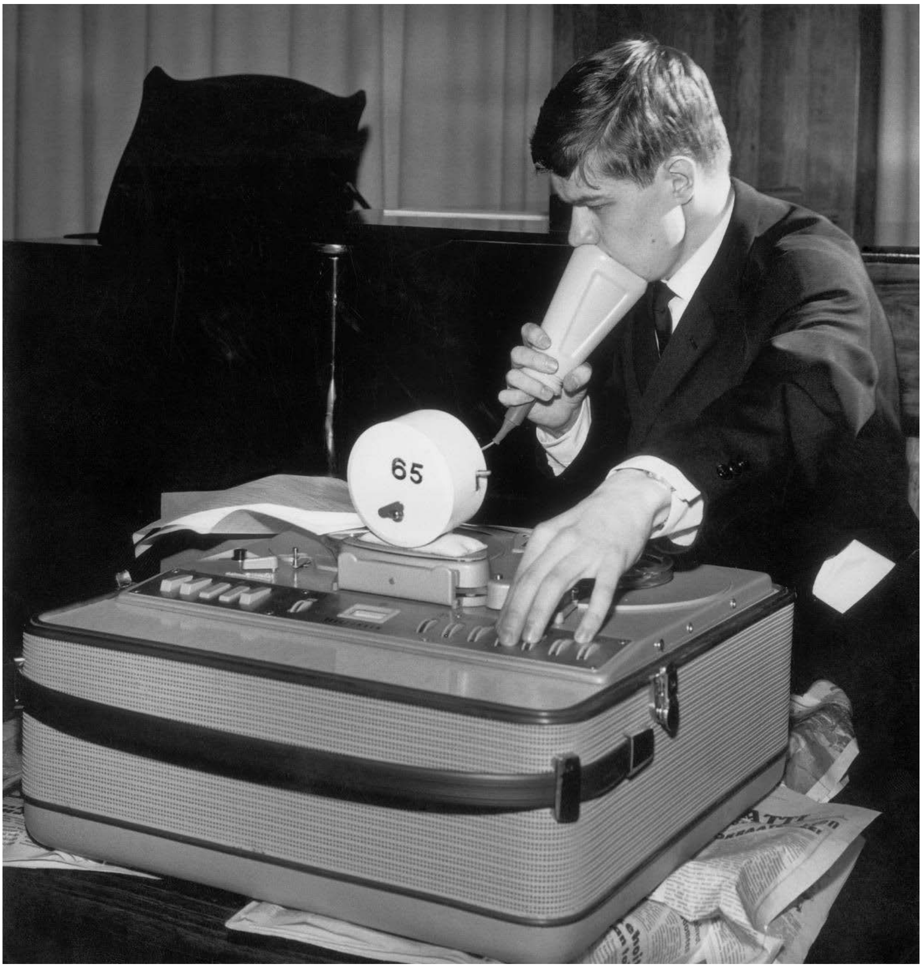

Figure 22. M.A. Numminen performing his avant-garde works *Ontogim* and *Oigu-S* (1964) in the academic singing contest held on April 4, 1964; the Laulukone (Engl. Singing Machine; not seen in the picture) was operated by Kullervo Aura. On top of the Telefunken M24 tape recorder, which they borrowed from the University Studio, Numminen has a chess clock where they can follow the time-based score.[197] The photo originally published in the magazine *Viikkosanomat* N:o 15 on April 10, 1964 (photo: Matti Tapola / Lehtikuva[198])

[196] Numminen (2018) in an interview with Ojanen. See also Kivinen (1967, 91); Tawaststjerna (1967 [funding application, January 26, 1967]).
[197] Numminen (2018) in an interview with Ojanen.
[198] Lehtikuva archive ID: 4160308; Date Created: n/a; Creator: Matti Tapola.

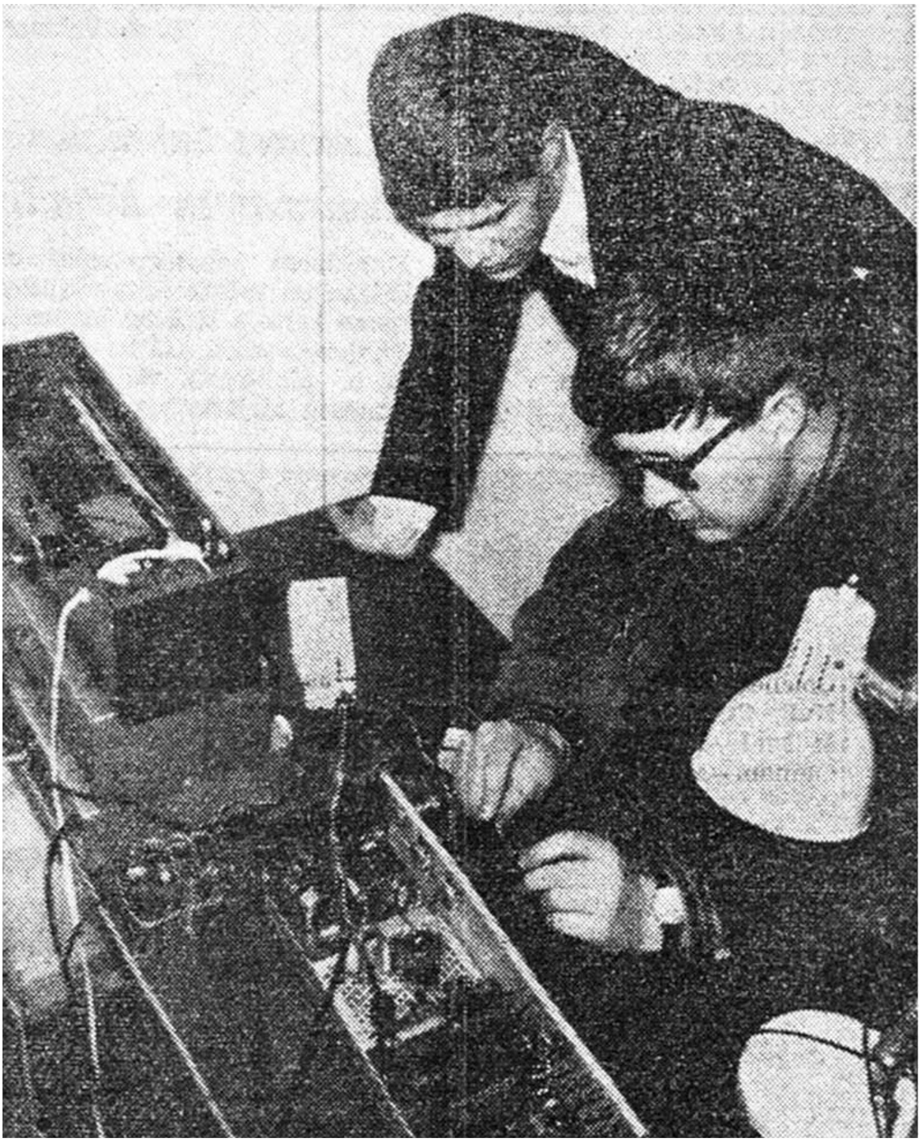

Figure 23. M.A. Numminen and Kullervo Aura with the Singing Machine (photo: unknown / *Uusi Suomi*[199])

[199] Photo published in *Uusi Suomi* on April 5, 1964; the location is unknown (see *Uusi Suomi*, 1964, 20). The original caption: Ylioppilaiden Kulttuurikilpailut alkoivat eilen musiikkikilpailuilla. Päivän aikana kilpailtiin yksinlaulun sekä orkesterien ja kamariyhtyeiden sarjoissa. Kilpailut jatkuvat tänään. – Yksinlaulukilpailuun osallistunut Mauri A. Numminen esitti vapaavalintaisina numeroina omia sävellyksiään, joissa säestäjänä toimi magnetofoni. (Engl. The Student Cultural Competitions started yesterday with music competitions. Competitions held during the day included solo singing as well as the singing in orchestra and chamber ensemble series. The event contin-

TV documentarian Aki Oura[200] interviewed Kurenniemi in the first Vironkatu studio setup, presumably in October 1967. Moreover, Numminen posed with a zither and the nearly finished Sähkökvartetti on his lap in front of the studio equipment in the first or second Vironkatu studio setup on July 15, 1968 (see Figure 24). Even though the instrument was constantly being improved, and was never fully completed, it was performance-ready in late July 1968 when Numminen took it to Bulgaria with him. (Lindfors & Salo 1988, 86–87; Suominen 2013, 135–138; for a detailed description of the usability of the instrument see Ch. 6.2.2)

Numminen mainly used the instrument with his band Sähkökvartetti, i.e. M.A. Numminen (processed singing), Tommi Parko (electric saxophone and violin), Arto Koskinen (melody machine), and Peter Widén (electric drums). Sähkökvartetti typically played one improvised piece entitled *Kaukana väijyy ystäviä* (1968, Engl. Far Lurking Friends), the duration and structure of which varied from one performance to another. Lindfors (2016, [22]) refers to a concert review by Oramo[201], who also reviews another work played by Sähkökvartetti entitled *Jospa kuu ja vesi nousevat kerran* (Engl. If the moon and the water rise once). According to Numminen, the work was accompanied by a prerecorded background tape on which each member of the band sang his own vowel sound (see also Lindfors 2016, [22]).[202] Numminen sings the phrase "Jospa kuu ja vesi nousevat kerran" as a part of the performance of *Kaukana väijyy ystäviä* on November 25, 1968 in the *Kommunikaatiokonsertti* (Engl. Communication concert) in the University of Helsinki Great Hall, which underlines the casual realization of their works and hints that they also blended with each other in improvised performances.

Sähkökvartetti premiered at *the 9th World Festival of Youth and Students* held in Sofia, Bulgaria, July 28 – August 8, 1968.[203] It was reported that hundreds of audience members walked out of the concert hall during their show.[204] During its existence, the band performed in only ten or so of their own concerts, but the instrument was also used at various events by underground art group Suomen Talvisota 1939–1940, which consisted of Numminen's Underground rock quartet and contemporary underground artists such as Markku Into (1945–2018) and Jarkko Laine (1947–2006).

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ues today. – Mauri A. Numminen, who was in the solo competition, performed his own compositions as optional numbers, accompanied by a tape recorder.)

[200] Documentary film *Kahdeksan tahtia tietokoneelle* in the Yle archive; Name of the program: Kahdeksan tahtia tietokoneelle (Engl. Eight bars for a computer). Media ID: MEDIA_2012_00467326; Program ID: PROG_2009_00123373; First aired on October 27, 1967. Director: Aki Oura.

[201] Oramo (1968, 19/*HS* September 29, 1968).

[202] Numminen (2018) in an interview with Ojanen.

[203] See *HS* (July 14, 1968, 15).

[204] See *ESS* (August 11, 1968, 7); *Stump* (1968b, 19).

Figure 24. M.A. Numminen in the Vironkatu studio with zither and the almost-finished Sähkökvartetti on his lap, July 15, 1968. The modular rack of unidentified University Studio equipment behind Numminen. The same rack is visible on the pictures from the Sähköshokki-ilta event in the Amos Anderson Art Museum on February 9, 1968 (see Figure 112) (photo: Pekka Haraste / Lehtikuva[205])

[205] Lehtikuva archive ID: 1928201; Date Created: 19680715; Creator: Pekka Haraste.

Sähkökvartetti (the band) was active until the early 1970s. Two concert recordings[206] and an excerpt recorded by Yle for a TV documentary Ungdom för helvete! (1969) with Sähkökvartetti have survived. After a 30-year hiatus, the band made one public performance with its original line up at the Avanto festival in 2002. A complete list of Sähkökvartetti performances is under construction: those that have been identified are catalogued in the Appearances of Kurenniemi's Electronic Musical Instrument data set.[207]

Sähkökvartetti (the instrument) was also used in the University Studio as a sound source during the active period of Sähkökvartetti (the band). The instrument had the leading role in Yle's documentary training project from early 1969,[208] which presented Donner's musical activities.[209] Kurenniemi used the instrument in 1969 to produce the soundtrack for Risto Jarva's educational commercial film *Pakasteet* (1969; Frozen Foods), and in 1971 Donner used sounds from Sähkökvartetti, DIMI-A and DIMI-O in a radio play entitled *Vihreä eläin*[210] based on the text of architect Marja Vesterinen (b. 1937) (Ruohomäki 2013, 14). The instrument was also used on February 27, 1974 in a live performance by Jukka Ruohomäki of his semi-improvised work *Talviunesta herääminen* (1974; Engl. Waking up from hibernation), featuring Olli Ahvenlahti (Minimoog), Mircea Stan (trombone), and Kurenniemi (VCS 3, and Sähkökvartetti with Ruohomäki) in a taped concert organized by Yle at the Liisankatu Studio.

The instrument is also to be heard in an improvised studio session[211] recorded as student work for the studio technology course in 1973, and it remained in use in the University Studio until Vesterinen broke the power-supply unit.[212] After that, it remained with Numminen in a non-working condition until 2002, when it was restored along with some of Kurenniemi's other instruments: it is currently located, and is frequently played in the University Studio.

[206] *Kommunikaatiokonsertti* at the University of Helsinki on November 25, 1968 (released on *Taisteluni* by Numminen 1970); *Sähköinen tapahtuma Vanhalla* on November 17, 1970 (Yle's archive ID: 000053962).
[207] Available at https://doi.org/10.5281/zenodo.842854.
[208] See Chapter 5.1.4.
[209] However, it is interesting that Kurenniemi's oral presentation and audible electronic soundtrack do not seem to match any known studio equipment at the time. The Sähkökvartetti drum machine can be identified on the soundtrack, but otherwise Kurenniemi's description of the functionalities accompanied by the instrument sound refers to an unidentified design.
[210] Radio play in Yle's archive; ID: 000096478; Recording date: 1971.08.17.
[211] The improvisation session of the studio course, December 10, 1973 (Music Finland sound-recording archive CD 5261). The session was attended by Veikko Kumpula (Sähkökvartetti), Antti Ortamo (VCS3), Heikki Valkonen (VCS3), Olavi R? (DIMI-A), Arja Vanajas (DIMI-O), Jyrki Vuokko (DIMI-T and recorder), Jukka Ruohomäki (äänitarkkailu = sound engineering) and Erkki Kurenniemi (kannustus = encouragement).
[212] Ruohomäki (2014) in an interview with Ojanen.

5.2.2 Andromatic: the automatic Andromedean and Swedish composers Ralph Lundsten and Leo Nilsson

Swedish composer Ralph Lundsten started working on electronic music in the late 1950s. With his associate, composer Leo Nilsson, they built the Andromeda electronic music studio[213] near Stockholm during the 1960s. Nilsson and Kurenniemi met in March 1963 during a seminar at *Stockholms Elektroniska Festspel*. The three started collaborating at the latest during the Jyväskylän Kesä algorithmic seminar in July 1965, and their close collaboration lasted until Nilsson started to build his Viarp Studio in the early 1970s. Nilsson recalls that he used at least three versions of Kurenniemi's music machines.[214] Kurenniemi's collaboration with Lundsten continued during the 1970s.

According to Lundsten's notes, Kurenniemi started to desing a new instrument for them in the fall of 1967.[215] Nilsson also recalls Kurenniemi's visit to Stockholm in 1967.[216] According to Dahlberg in *Dagens Nyheter*, the concrete building process started in August 1968[217] and Kurenniemi completed the instrument that Lundsten and Nilsson named Andromatic in the fall of 1968. The name derives from the Swedish phrase *den automatiska Andromedaren* (Engl. automatic Andromedean, Andromedean referring to Lundsten and Nilsson's Andromeda Studio) (Städje 2012) (see Figures 25–31).

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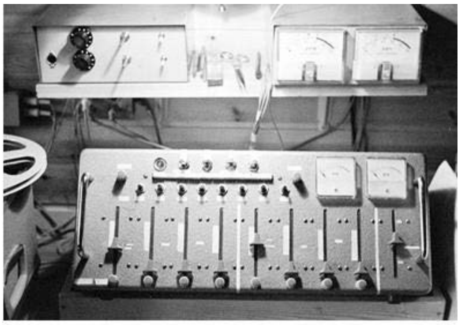
[213] The name Andromeda appears for the first time in the liner notes of the sound recording *Elektronisk Musik* (1968; His Master's Voice CSDS 1085) by Ralph Lundsten and Leo Nilsson. Their two previous records were released by Swedish Radio. Their first record released to the general public was *Elektronmusikstudion: Dokumentation 1* (1966; LPD1), and produced in SR:s Elektronmusikstudion (Engl. The Swedish Radio Electronic Music Studio). The liner notes of the second sound recording *MUMS: Musik Under Millioner Stjärnor* (1967; Sveriges Radio RELP 5023) do not name the specific studio in which it was produced.

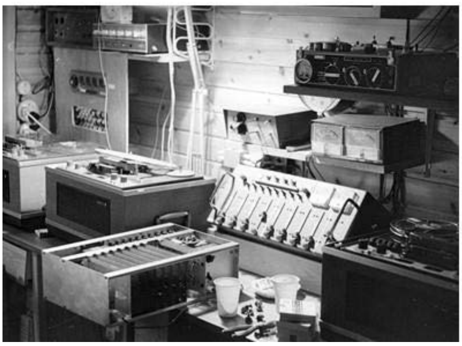
[214] Nilsson (2019) in an interview with Ojanen.

[215] Lundsten (2018) in an interview with Ojanen.

[216] Nilsson (2019) in an interview with Ojanen.

[217] Dahlberg (1968, 6).


Figures 25–30. A photo set in Kurenniemi's archive. Kurenniemi presumably took the photos in the Andromeda Studio during his trip to Stockholm to deliver the Andromatic to Lundsten and Nilsson in the fall of 1968 (photos: presumably by Erkki Kurenniemi / The Finnish National Gallery / Erkki Kurenniemi archive)

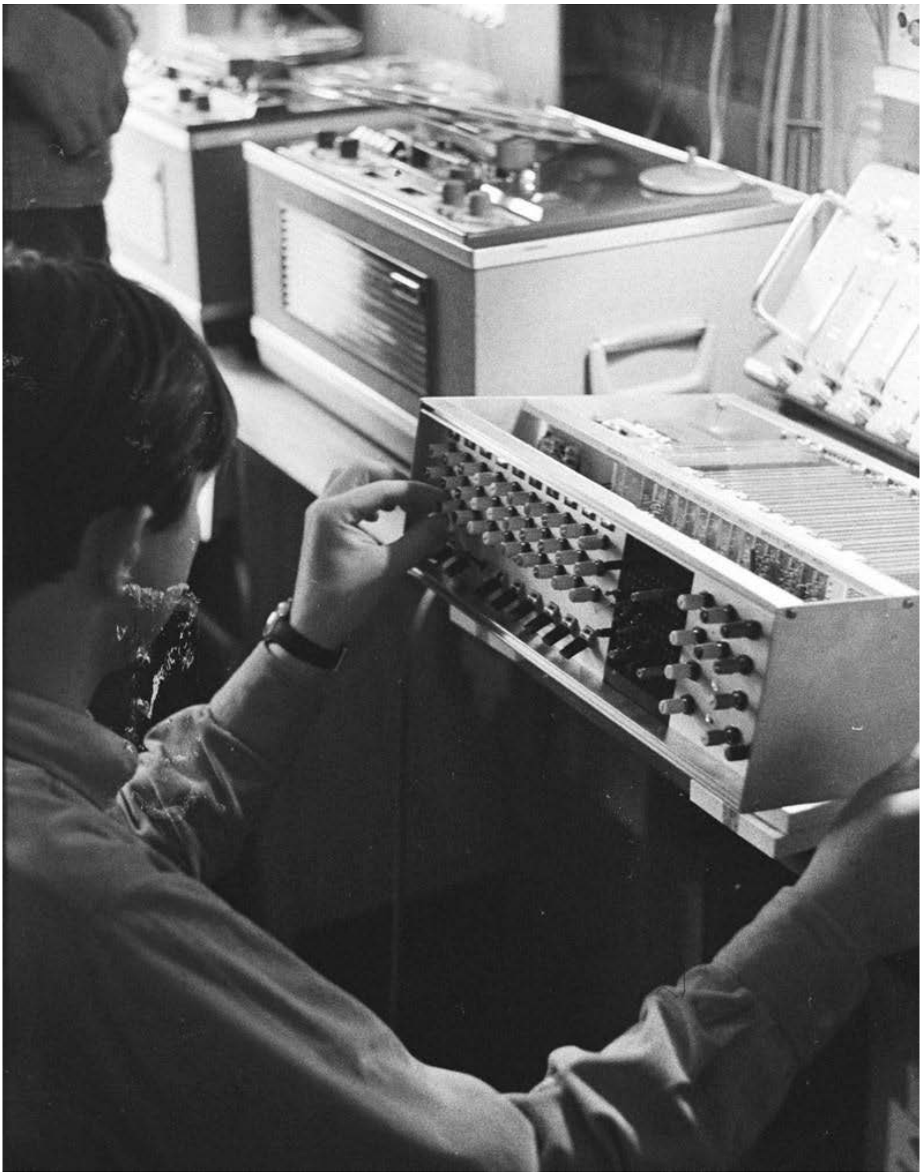


Figure 31. Composer Leo Nilsson trying out the newly finished Andromatic in the Andromeda Studio in the fall of 1968 (photo presumably by Erkki Kurenniemi / The Finnish National Gallery / Erkki Kurenniemi archive)

Lundsten wanted an instrument without a conventional piano keyboard. He did not wish to restrict himself to twelve-tone music and standard Western scales (Städje 2012; Suominen 2013). Nilsson recalls that they pondered upon the idea of electronic musical instruments in general with Kurenniemi on several occasions during the 1960s. Even though their original purpose was to produce concrete music in the Andromeda Studio, they commissioned an electronic music instrument from Kurenniemi that allowed the user to produce and control "longer series of frequencies, amplitudes and waveforms".[218]

Otherwise, the detailed background of the design remains unknown. Kurenniemi mentioned in 2004 that their retrospective views of the original design ideas collided with Lundsten's.[219] Lundsten, however, emphasizes his admiration of Kurenniemi's unchained creativity (Städje 2012). Lundsten, Nilsson, and Kurenniemi brainstormed the initial ideas for the instrument, on the basis of which Kurenniemi realized the instrument according to his plans. (For a detailed description of the functionality and usability of the instrument, see Chapter 6.2.2.)

Kurenniemi made a recording with the Andromatic instrument before carrying it to Stockholm in a cardboard box.[220] His aim was presumably to

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[218] Nilsson (2019) in an interview with Ojanen: "Erkki var inbjuden till Fylkingen (föreningen för experimentell musik i Stockholm), (1967 tror jag), för att hålla ett anförande och diskutera möjligheterna för att bygga upp en elektronmusikstudio - (EMS). Vi fick bra kontakt, och började också fundera över elektroniska musikinstrument i allmänhet. Vid den tiden samarbetade jag med Ralph Lundsten. Vi hade tillsammans byggt upp en studio, Studio Andromeda, för att i huvudsak arbeta med sk. Konkret musik. Vi diskuterade nya konstruktioner med Erkki och han ville då gärna försöka bygga en "sequenser" där man kunde styra frekvens, amplitud och vågform (klangspektra) för en längre serie positioner. Detta måste ha varit någon gång 1967. Erkki åkte till Helsingfors och efter några månader kom han tillbaka med det första exemplaret som vi döpte till Andromatic. Detta lilla, men lättanvända instrument, blev tillsammans med studions övriga faciliteter ett kraftfullt instrument. Många kompositioner från den tiden som lämnade Studio Andromeda hade ljudmaterial i sig som utgick ifrån Andromatic och sedan var vidare bearbetade. Vi använde också Andromatic direkt i utställningar och konserter. Erkki byggde sedan fler och mera utarbetade versioner av sitt instrument." (Engl. Erkki was invited to Fylkingen (The Association for Experimental Music in Stockholm), (I believe in 1967), to give a speech and discuss the possibilities of building an electronic music studio - (EMS). We established contact and began to think about electronic musical instruments in general. At that time I was collaborating with Ralph Lundsten. We had built a studio, Studio Andromeda, together, the idea being mainly to work with so-called concrete music. We discussed new designs with Erkki, and he wanted to try to build a "sequencer" where you could control longer series of frequency, amplitude and waveform (sound spectra). This must have been sometime in 1967. Erkki went to Helsinki and after some months he came back with the first copy, which we named Andromatic. This small but easy-to-use artifact, in combination with the studio's other facilities, became a powerful instrument. The sound material of many of the compositions that left Studio Andromeda at the time was from Andromatic and was further processed. We also used Andromatic directly in exhibitions and concerts. Erkki then built more and more elaborate versions of his instrument.)

[219] Kurenniemi (2004) in an interview with Ojanen & Suominen.

[220] Kurenniemi (2004) in an interview with Ojanen & Suominen. See also a series of photographs in Kurenniemi's collection in FNG/EKA depicting the arrival of Andromatic at the Andromeda

produce material for the commissioned album *Perspectives ’68: Music in Finland* (Love records, LRLP 4), which was released jointly by The Student Union of the University of Helsinki (HYY) and the newly founded record label Love records to honor the 100th Anniversary of HYY in November 1968. The production of the album and collaboration with Love records were settled at the meeting of the HYY executive committee on June 19, 1968.[221] Meanwhile, the draft contract between HYY and Love records and the initial production plan for the album contents were discussed by the anniversary planning committee on May 30, 1968. The contents of the final album are mainly in line with the initial plan, although the draft contents only have a placeholder for Kurenniemi’s work, indicating that Kurenniemi would produce an electronic composition with the University Studio’s music machine that would last approximately seven minutes.[222]

Later on, Kurenniemi selected three segments from the tape he recorded with Andromatic and simply spliced them together without further processing to complete the commissioned work. The eventual title of Kurenniemi’s work on the album was *Antropoidien tanssi* (Engl. Dance of the Anthropoids, 1968), and it was the first work for synthesizer and the second electroacoustic work to be released on a sound record in Finland. As a sound recording, *Antropoidien tanssi* was preceded only by Salmenhaara’s *Information Explosion* (1967), which was released by Love records in June 1967 (LREP 103). An excerpt from *Antropoidien tanssi* entitled *Dance of the Anthropoids* was issued in 1970 on the second album released by Finnish pre-progressive rock group Wigwam, entitled *Tombstone valentine* (1970, LRLP 19). The idea to include Kurenniemi’s track on the Wigwam album came from their producer Kim Fowley (1939–2015), who had heard it on the HYY compilation album.

Lundsten and Nilsson started touring Sweden with Andromatic on September 24, 1968.[223] The instrument was displayed in *Den Immateriella Processen* exhibition (Engl. Immaterial processes[224]), which opened on November 10, 1968 in Konstsalongen Samlaren in Stockholm[225] (see Figures 32 and 33).

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studio. The first one shows Lundsten holding a cardboard box on the doorstep of the Andromeda studio (see Figures 25–31).

[221] The HYY executive committee meeting on June 19, 1968: “Hallitus hyväksyi Komandiittiyhtiö Love-Recordsin kanssa 100-vuotisjuhlien yhteydessä julkaistavasta LP-levystä tehtävän sopimuksen.” (Engl. “The board approved an agreement with the limited partnership company Love records for the LP to be released at the 100th anniversary celebration.”)

[222] See the documents in the HYY archive: H_Hga_2_680530_sopimus and H_Hga_2_680530_sopimus_liite, https://doi.org/10.5281/zenodo.4290688

[223] Lundsten (2018) in an interview with Ojanen.

[224] See the invitation card of *Den Immateriella Processen*, Leo Nilsson archive.

[225] Dahlberg (1968, 6 / *DN* November 10, 1968); Lundsten (2014, 57).

Figure 32. The Andromatic in the exhibition *Den Immateriella Processen* (Engl. Immaterial Processes, 1968) in Konstsalongen Samlaren in Stockholm. The instrument and Olle Adrin's acrylic sculpture waiting to be assembled on a table. (photo: unknown / the Finnish National Gallery / Erkki Kurenniemi archive)

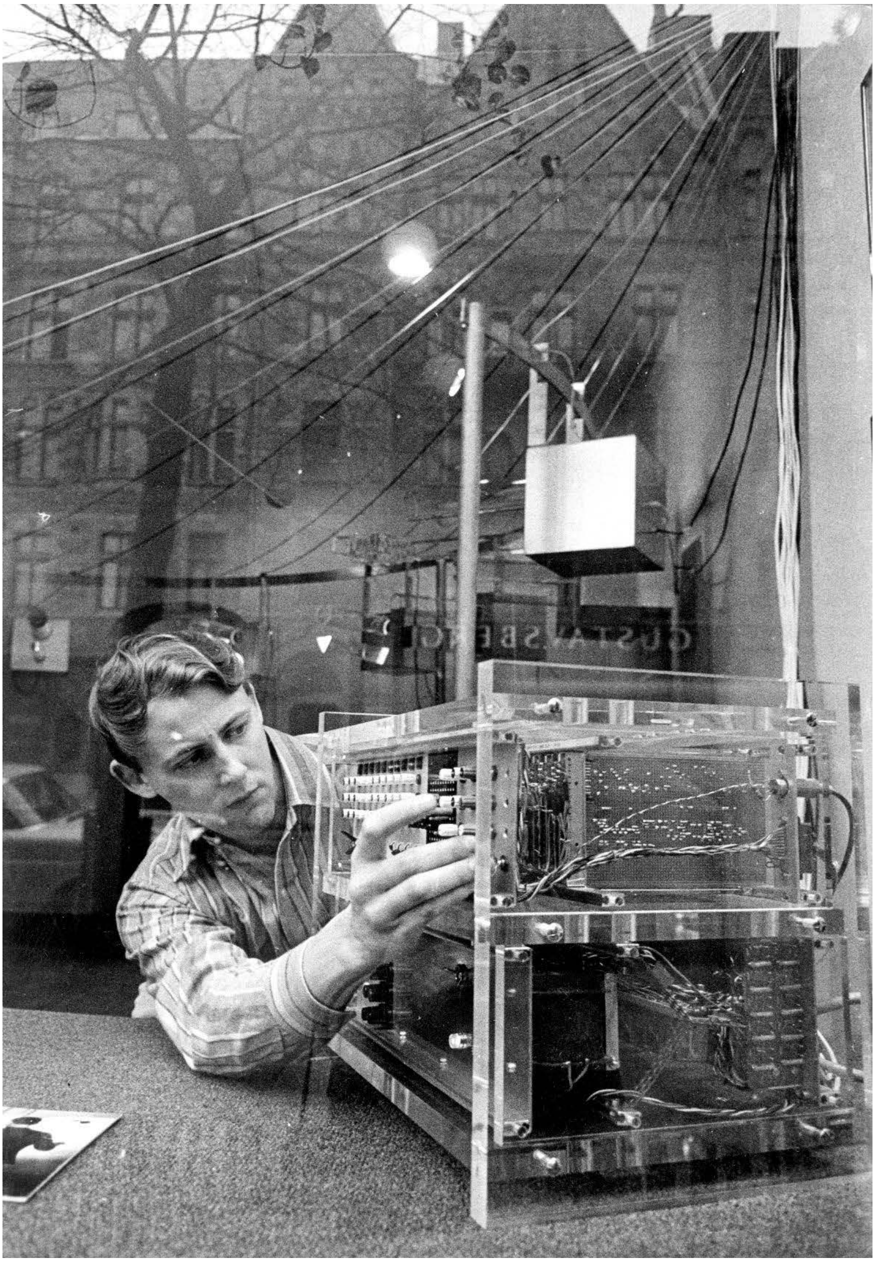

Figure 33. The Andromatic in the exhibition *Den Immateriella Processen* (Engl. Immaterial Processes, 1968) in Konstsalongen Samlaren in Stockholm. Assembled setup in the exhibition. Lundsten adjusting unidentified instrument parameter. (photo: unknown / Ralph Lundsten archive[226])

[226] Photo available via Andromeda website: https://www.andromeda.se/wp-content/uploads/2012/10/anmdromaticljusterminal.jpg

Shortly afterwards the instrument was part of the *Feel It* exhibition, first at the National Museum of Fine Arts in Stockholm in December 1968, and from January 24 to March 16, 1969 at the Museum of Contemporary Crafts in New York.[227] Andromatic was one among a larger group of works. The work entitled *Andromatic*, with the sub-title *[A] sculptural panel for your eyes and ears*, consisted of an acrylic sculpture of the instrument and Olle Adrin. Andromatic controlled the lighting of the sculpture and produced the music. The audience could interact with the work by modifying the switches and knobs on the instrument.[228] Lundsten and Nilsson also produced the two-piece electronic tape music work *Feel It* for the exhibition, which was released in 1968 as the first seven-inch single record in Sweden, and on January 30, 1969 as the special exhibition release accompanied with a 16-page booklet as the exhibition catalog.[229]

Andromatic returned to Sweden after the *Feel It* exhibition, and together with the sculpture setup was displayed at the Expo Norr festival in Östersund from June 28 to July 6, 1969 as part of the Rikskonserter series. Lundsten and Nilsson used the instrument among other sound sources, and realized the two-channel tape music work *Fågel Blå* (1969; Engl. The Blue Bird). The work was "commissioned by the Foundations for Nationwide Concerts to act as festival and inauguration music".[230] When they were composing the work Lundsten and Nilsson envisioned the sound coming from angels, hence, *Fågel Blå* was performed from two large balloons that were five meters in diameter "floating in the air over Östersund." Nordwall[231] described Lundsten and Nilsson's contributions as entertainment rather than art in his festival review. He was disappointed to report that the setup for *Fågel Blå* was completed a day after the opening, and that Andromatic did not work in the exhibition.[232]

Andromatic returned to Finland at least once when Kurenniemi used it in the *Elektrononstop* electronic music concert[233] organized by Yle at Vanha

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[227] Lundsten (2006, 53; 2014, 57); see also the American Craftsmen's Council, Museum of Contemporary Crafts (1969): *Feel It - Press Release* https://digital.craftcouncil.org/digital/collection/p15785coll6/id/6547/rec/2

[228] American Craftsmen's Council. Museum of Contemporary Crafts (1968); https://digital.craftcouncil.org/digital/collection/p15785coll6/id/5876/

[229] *Feel It*, Andromeda edition, see: https://www.discogs.com/Ralph-Lundsten-And-Leo-Nilsson-Feel-It/release/2473419; *Feel It*, exhibition edition, see: https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Feel-It-Exhibition-Edition-/release/10416668

[230] Lundsten and Nilsson *Tellus/Fågel Blå* LP record sleeve https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Tellus-F%C3%A5gel-Bl%C3%A5/release/2215498

[231] Nordwall (1969, 16/*DN* July 3, 1969).

[232] See *DN* (April 26, 1969, 16); *DN* (June 12, 1969, 22).

[233] Elektrononstop is mentioned in Kurenniemi's daily planner entry on November 17, 1969 at 4 pm as "16.00 Nonstop" and on the bottom of the page he noted, "Nonstop n. 6 kelaa nauhaa (2 E.S-a.)" and "Nonstop materiaali takaisin!!" (Engl. Nonstop six reels of tapes, two Erkki Salmenhaara; Return Nonstop material!!). It remains unresolved whether the markings refer to material recorded at Elektrononstop or to the tape works reproduced at the tape music concert that was

Ylioppilastalo (Engl. The Old Student House) in Helsinki on November 17, 1969. Composer Osmo Lindeman and Kurenniemi presented the electronic music equipment as part of this six-hour event. Unfortunately, no audio, film or photographic documents have survived, thus no closer analysis of the event is possible. Ruohomäki (2020, EH36/6), who attended the concert, was impressed by the vivid patterns and interaction of the players when Kurenniemi and Lindeman performed with Andromatic and DICO (see Chapter 5.2.3), respectively. Ruohomäki considered the performance a success. Salmenhaara[234] wrote a positive review of the event and described Kurenniemi and Lindeman as presenting electronic music equipment, but he did not specifically mention the instruments that were used.

For Lundsten, Andromatic was irreplaceable as a sound source in his Andromeda studio, where he used it for almost 50 years. He utilized the sound from the instrument in literally dozens of works – in addition to the abovementioned examples in *Robot Parade* (1968), the seven-piece *Erik XIV* (1969), *Through a Landscape of Mirrors* (1970), the nine-piece *Gustav III* (1971), *Nattmara* (1970), *Shangri-La* (1973), *Brain Safari* (1976), *The Hot Andromedary* (1976), *Listen The Space Sneaker* (1976), *Discophrenia* (1978), *Ego Love Song* (1979), and *Horrorscope* (1979). He declared in 2012 that Andromatic was "the best synthesizer in the world".[235] The Andromeda studio was dismantled in 2014 and Lundsten donated the instrument to Musikmuseet in Stockholm. Both Nilsson and Lundsten contributed to Kurenniemi's instrument-design process. Lundsten's collaboration with Kurenniemi continued after Nilsson left the Andromeda studio to build his own Viarp Studio in the early 1970s (see e.g. Sandlund 2019). Lundsten participated in the design of the DIMI instruments, and eventually purchased four of them to complete the Andromeda studio collection amid Andromatic (see Figure 34; see also Chapter 5.3).

part of it. Erkki Salmenhaara (1969) wrote a review of the event in Helsingin Sanomat. It is notable that Fylkingen used the name Electrononstop in their concert series in the 1960s.
[234] Salmenhaara (1969, 16)/*HS* 19.11.1969).
[235] Lundsten (2012) in an interview with Ojanen & Ruohomäki.

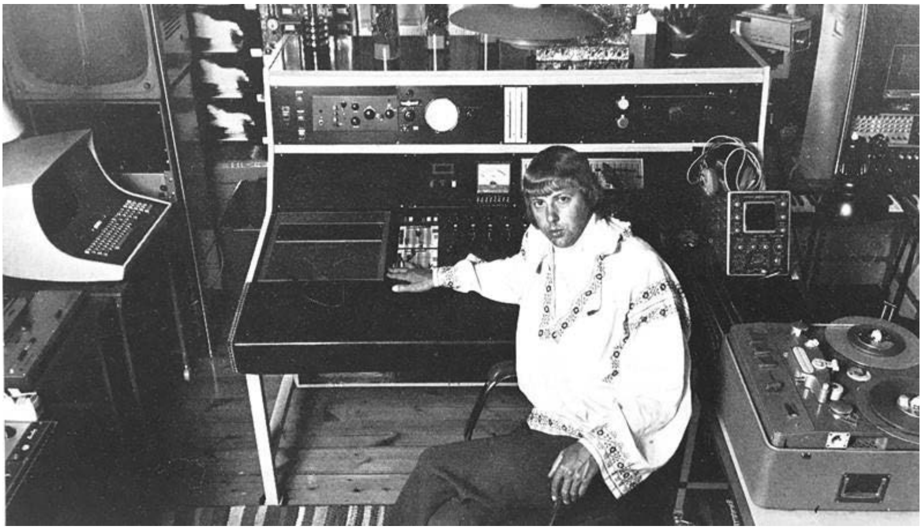

Figure 34. Composer Ralph Lundsten in his Andromeda studio sometime between 1975 (the completion of the DIMI 6000) and 1978 (the donation of the DIMI-A to the Musikmuseet). Kurenniemi's instruments seen from left to right: the DIMI 6000 ADDS terminal (far left side of the photo), the DIMI-A integrated into the mixer console (close to Lundsten's right hand), the DIMI-O camera (the upper right corner of the photo), the Andromatic (far right side of the photo, under the DIMI-O video monitor), the DIMI-O keyboard underneath the Andromatic. (photo: unknown / originally published in *Otavan iso musiikkitietosanakirja*[236])

5.2.3 Osmo Lindeman's early home studio setup and the DICO digitally controlled oscillator

Osmo Lindeman (1929–1987) was a classically trained composer and music pedagogue, who received his composition diploma from the Sibelius Academy in 1958. Before commencing his career as a composer, he was a jazz pianist and recorded Latin American music with several groups. He studied composition in the Sibelius Academy with Nils-Erik Fougstedt, and in the State Institute of Music in Munich with Carl Orff in the early 1960s as an UNESCO grantee[237]. During the academic year 1976–77, Lindeman visited the University of Illinois and the University of Columbia, New York, where he studied electronic music as a Fulbright-Hays Visiting Scholar.[238] (Ruohomäki 2020, EH36/1; Juva 2008, 111)

Lindeman's repertoire for orchestra includes works such as two symphonies[239], two concertos[240], several works of chamber music[241], and *Variabile*

[236] See Ala-Könni et al. (1978, 123).
[237] Lindeman won the UNESCO grant as a prize for his first Symphony (1959).
[238] See FIMIC (1979), composer brochure in the UHMRL archive.
[239] Symphony No. 1 *Sinfonia inornata* (1959), Symphony No. 2 (1964)
[240] Concerto No.1 for piano and orchestra (1963), Concerto No. 2 for piano and orchestra (1965)

for orchestra (1967). Adding to his works for classical and contemporary orchestra Lindeman composed several film scores, notably for directors Matti Kassila[242] and Eino Ruutsalo[243] – as well as for Ritva Arvelo,[244] Aarne Tarkas,[245] Maunu Kurkvaara,[246] and Valentin Vaala.[247]

Even though Lindeman had been teaching music theory at the Sibelius Academy since 1961, he did not start to run courses on electronic music until 1972. Composer Otto Romanowski (b. 1952), who started his studies at the Academy in 1972, recalls that electronic music was not appreciated there at the time, and even Lindeman's new courses were not unreservedly appreciated.[248] According to Lindeman's promotional texts published in the Sibelius Academy's in-house journal, as well as in *Rondo* music magazine, his courses in 1973–74 were entitled *Elektroniikka I* (Engl. Electronics I), *Elektroniikka II* (Engl. Electronics II), *Tietojenkäsittelyopin peruskurssi* (Engl. Basic course in computing), *Tietokoneen ohjelmointi* (Engl. Computer programming), and *Tietokonemusiikin matematiikka* (Engl. The Mathematics of Computer Music). Given its negative attitude towards the new (electronic) music, the Sibelius Academy did not invest in any equipment, therefore Lindeman's courses were theoretical and based on simulation. However, the University Studio provided facilities for hands-on experiments and most of Lindeman's students also took the university courses that Ruohomäki and Kurenniemi started to organize in 1972.[249]

As a teacher and composer of electronic music, Lindeman felt that he had to invent everything by himself, including the themes he taught and the language for his electronic works (Ruohomäki 2020, EH36/7–8).[250] He published several course materials such as *Tietojen käsittelyopin peruskurssi*,[251] *Digitaalitekniikka*[252] and *Elektronisen musiikin teknologia*.[253] He also translated Knut Jeppesen's *Kontrapunkt* into Finnish in 1972, published a text book on music theory (1976, *Johdatus musiikin teoriaan*) and a book about

[241] String Trio (1958), String Quartet (1966), Music for Chamber Orchestra (1966), Concerto for Chamber Orchestra (1966), Partita for Percussion (1962), Two expressions for vibraphone and marimba (1965).
[242] *Punainen viiva* (1959), three Komisario Palmu movies (1960–1962), *Tulipunainen kyyhkynen* (1961), *Kolmen kaupungin kasvot* (1962).
[243] *Puhuvat kädet* (1959), *Hetkiä yössä* (1961), *Herra Adam käy Suomessa* (1966), *Tämäkö on teddy-karhun maailma?* (1969).
[244] *Kultainen vasikka* (1961).
[245] *Minkkiturkki* (1961).
[246] *Rakas...* (1961).
[247] *Totuus on armoton* (1963).
[248] Romanowski (2019) in an interview with Ojanen.
[249] See also Sirkka Lindeman (1996) in an interview with Ruohomäki.
[250] Lindeman's interviews with Koskimies (1972), Paalanen (1974), Sermilä (1975) and Santalahti (1980).
[251] Lindeman (1972).
[252] Lindeman (1973).
[253] Lindeman (1974).

electronic music entitled *Elektroninen musiikki*,[254] which was a rare release in Finnish – even in 1980 when it was published.

Lindeman decided to abandon composing orchestral works in 1968, shortly after the premiere of *Variabile* (1967), which was his last work for orchestra. It was premiered on December 7, 1967 during the 50th-anniversary concert of Suomen Säveltaiteilijain liitto (Engl. The Finnish Composers' Union), performed by The Helsinki Philharmonic Orchestra under the baton of Jorma Panula in the Great Hall of the University of Helsinki. Lindeman used graphic notation in *Variabile*, which has been described retrospectively as representative of his "transition from traditional instrumental resources towards electronic music"[255] (see also Riikonen 1978, 9–11). The notation caused several problems in the rehearsals and eventually even caused the concert performance to be interrupted.[256]

Annoyed by these experiences Lindeman wondered why the composer was dependent on the orchestra and the conductor. He left for Poland shortly after the concert, where he came across electronic music scores by composer and music teacher Andrzej Dobrowolski as well as the writings of composer, music theoretician and teacher Boguslaw Schaeffer. Lindeman met Dobrowolski and spent most of his two-week trip in the electronic music studio of the Warsaw school of music. He came to his decision during that period, and thereafter he focused only on electronic music.[257] (Riikonen 1978, 9–11)

Lindeman's tape music concert in the Porthania music hall on November 7, 1969 was reviewed by Wahlström[258], who interviewed the composer. Lindeman talked about his interest in music constructed with an automatic rhythm machine, even though "it was designed as a joke". According to Kurenniemi's daily diaries, Lindeman met Kurenniemi on July 22, 1968[259] – just as Kurenniemi and Numminen were finishing Sähkökvartetti before its premiere in Bulgaria. At that point the Andromatic was at least on the drawing board, as Kurenniemi delivered the instrument to Stockholm in September. Either of these instruments may well have inspired Lindeman's "rhythm machine", but it is not known whether he was specifically referring to Kurenniemi's designs in Wahlström's review. Nevertheless, he thought that he could develop the idea of automated music further. He asked Kurenniemi to

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[254] Lindeman (1980).
[255] See FIMIC (1979) composer brochure; see also Lindeman's scrapbook: Lindeman, Osmo, Lindeman, Sirkka, & Ojanen, Mikko. (2020). *The Scrapbook of Osmo Lindeman: catalogued and annotated contents with sample pictures* [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3886432.
[256] Lindeman (1975) mentions the interruption in his interview with Sermilä on February 5, 1975, however, none of the concert reviewers attached to Lindeman's scrapbook mention the work being interrupted. The newspaper clippings, of which publication details have not been documented, include reviews by Erik Tawaststjerna, Seppo Nummi, and pseudonyms V.V., Her, and aa.
[257] Lindeman (1975) in an interview with Sermilä.
[258] Wahlström (1969, 11/*Hbl* November 11, 1969).
[259] See Kurenniemi's daily planner 1968.

help when he wanted "a similar automated melody machine"[260] for his home studio setup, which was still quite modest with a couple of pieces of equipment located on the living room bookshelf (Ruohomäki 2020, EH36/6).

Home studios were rare at the time, most of the setups being developed and maintained by universities or national radio broadcasters. Lindeman's home studio was pivotal for him. He did not want to book studio time weeks beforehand, but he did want to have all his own equipment available when the inspiration arose – any time of the day or night. He also appreciated the comfortable working environment, where he could be in his dressing gown without leaving home. Lindeman moved to a new apartment with his family in the early 1970s, where he designated one room as an electronic music studio (see Figures 35 and 36).[261]

Kurenniemi finished the digitally controlled synthesizer-sequencer for Lindeman in early 1969 at the latest. The instrument has variously been referred to as DICO, DCO, LDCO and Digo, L possibly referring to Lindeman[262] (Riikonen 1978; Suominen 2013). As with Kurenniemi's other designs, DICO was modified after the first version was completed: it even went back to Kurenniemi in early 1970.[263] For a detailed description of the functionalities and usability of the instrument, see Chapter 6.

The first work that Lindeman realized with the DICO was probably a half-hour tape with electronic music for the international *Valo ja liike 2* (Engl. Light and Movement 2) exhibition organized by Eino Ruutsalo in the Amos Anderson Art Museum, May 30 – June 8, 1969. Lindeman entitled the work *Mobile*[264], and it was repeatedly reproduced from the tape in the exhibition. He shortened it later and entitled it *Kinetic Forms* (1969), and as such it was premiered with *Mechanical Music for Stereophonic Tape* (1969[265]) in Yle's

[260] Wahlström (1969, 11/*Hbl* November 11, 1969).
[261] Wahlström (1969, 11/*Hbl* November 11, 1969); Lindeman (1972) in an interview with Koskimies; Lindeman (1975) in an interview with Sermilä.
[262] Kurenniemi's daily planner for 1969.
[263] Kurenniemi's daily planner, February 12, 1970; also, Sirkka Lindeman's (1996) interview with Ruohomäki.
[264] The description of *Mobile* in the *Valo ja liike 2* exhibition catalog: "Näyttelyssä kuultavan elektronisen musiikin on säveltänyt Osmo Lindeman (s. 1929) Helsingistä. Teoksen nimenä on 'Mobile' ja säveltäjä mainitsee siitä seuraavaa: Sävellys on rakennettu puhtaasti elektronisista äänistä. Ne on taltioitu erilaisista äänigeneraattoreista, joista yksi on varustettu elektronisin muistiyksiköin. Saatu sävelmateriaali on muokattu uudelleen 'sekoittaen' sekä erilaisia suodattimia ja kaikulaitteita käyttäen lopulliseen muotoonsa."
(Engl. "Osmo Lindeman (b. 1929) from Helsinki, Finland, composed the electronic music heard at the exhibition. The title of the work is 'Mobile' and the composer describes it as follows: The composition is built purely from electronic sounds. They are recorded from various sound generators, one of which is equipped with electronic memory units. The resulting melody material has been remodelled to 'blend', using various filters and echoes, to its final form.")
[265] Also known as *Computer Music for Stereophonic Tape* (Yle archive: Programme ID 000102029) or *Datamaskinmusik för stereoband* (Wahlström (1969, 11/*Hbl* November 11, 1969). In contrast to my previous remark due to insufficient analysis (see Ojanen & Suominen 2005, 24, footnote 20), Lindeman did not employ the two-channel output of the instrument. It appears in his works as a point source signal.

tape music concert on November 7, 1969. Lindeman's other early works with the DICO include *Tropicana* (1970), *Midas* (1970), the sound designs for the TV commercials *Sunkist* and *Finn-Humus*, and the musical logo for the national TV news that was used by Yle throughout the 1970s.

Figure 35. Composer Osmo Lindeman in his home studio in 1972 The "comunicato" of the 1st prize for *Ritual* hanging on the wall behing the work lamp next to the poster of ascenting Apollo 11 Lunar Module. The DICO located in a central place in the middle of the setup. (photo: Sirkka Lindeman / originally published in *Tiedon värikäs maailma*[266])

[266] See Virtaranta et al. (1973, 192). The original caption: "Säveltäjä Osmo Lindeman yksityisessä elektronimusiikin studiossaan. Kuvassa nähdään mm. erityyppisiä äänigeneraattoreita, äänentarkkailu- ym. mittareita, oskilloskooppi, suodin jne. Keskellä oleva laite, jossa palaa pieniä tarkkailulamppuja, on äänigeneraattori, jonka rakenne perustuu tietokonetekniikkaan. Tämä ns. digitaalioskillaattori sisältää oman muistiyksikön, ja laitetta ohjataan binaarikoodilla. Kuvassa olevan studion laitteisto ei kansainvälisessä vertailussa läheskään sijoitu laajimpien ja kalleimpien joukkoon. Elektronisen musiikin sävellystyössä ei ratkaiseva tekijä kuitenkaan ole laitteiden lukumäärä ja kalleus, vaan niiden tarkoituksenmukaisuus sekä tietenkin säveltäjän mielikuvitus ja laitteiston käyttötaito. Tästä on mm. todisteena kuvassa seinällä kehyksissä oleva 'comunicato' Lindemanin

Figure 36. Lindeman's home studio setup in 1975. The DICO companied by the EMS VCS 3 Mk III. The DICO input for the external signal was connected in 1972, but not in 1975. (photo: unknown / originally published in *Otavan iso musiikkitietosanakirja*[267])

The material Lindeman originally produced for *Mobile* and *Tropicana* was used in the soundtrack of Eino Ruutsalo's short film *Tämäkö on teddy-karhun maailma?* (1969, Engl. Is This the World of Teddy Bear?) in 1969. It is not known whether Lindeman re-arranged the material himself or gave the *Mobile* and *Tropicana* tapes to Ruutsalo, who then edited the final soundtrack. In 1972, Lindeman produced the music for dancer Riitta Vainio's (1936–2015) two-part televised dance phantasy *Hummerit ja hummarit, Hummarit ja hammarit* (1972[268]). The first part of the work is based mainly

saamasta 1. palkinnosta suuressa kansainvälisessä sävellyskilpailussa elektronimusiikin kategoriassa Roomassa 1972."
(Engl. "Composer Osmo Lindeman in his private electronic music studio. The picture shows different types of sound generator, sound-monitoring and other meters, oscilloscope, filter, etc. The device in the middle, where the small monitoring lamps are lit, is a sound generator, the structure of which is based on computer technology. This so-called digital oscillator has its own memory unit, and the device is controlled by a binary code. By international comparison, the equipment in the studio in the picture is far from being among the most extensive and expensive. However, the decisive factor in the composition of electronic music is not the amount and cost of the equipment, but its appropriateness and, of course, the composer's imagination and the ability to use the equipment. This is evidenced in the 'comunicato' in the framed certificate on the wall for Lindeman's First Prize at the great international composition competition in the category of electronic music, held in Rome in 1972.")

[267] See Ala-Könni et al. (1978, 74).

[268] Name of the program: *Musiikkiykkönen: Hummerit ja hummarit. Hummarit ja hammarit*; Media ID: MEDIA_2016_01094581; Programme-ID: PROG_2009_00171786; Date: 19721006; Subject: *Kaksiosainen tanssifantasia* (Engl. A dance phantasy in two parts).

on sound material from *Mobile*, with some new DICO sequences and noise. The second part includes both concrete and instrumental as well as electronic sounds.

Kurenniemi and Lindeman attended the electronic music seminar on November 5, 1969, which was organized and recorded by Yle. The sound recording includes Kurenniemi's only documented use of the DICO, which he demonstrated for five minutes. The recording was later entitled *Improvisaatio* (1969) and was released on the album *Äänityksiä/Recordings 1963–1973*[269] (Love records LXCD 637). Only the direct signal from the instrument with its distinctive spring reverb was recorded – not the seminar room. Thus, it is impossible to verify whether or not Kurenniemi presented the instrument while he was playing. However, the casual nature of the document hints that he verbally described the instrument during the static first part of the recording and improvised with it after a sudden 12-second break (Ojanen & Lassfolk 2012, 6–7). Lindeman and Kurenniemi presented electronic music equipment and performed with the DICO and the Andromatic, respectively, in the *Elektrononstop* event organized by Yle in Vanha Ylioppilastalo in Helsinki on November 17, 1969 (see also Chapter 5.2.2 on the Andromatic).

Lindeman thought of his first electronic works as mere studies, and commissioned works or soundscapes for different purposes such as exhibitions, commercials and TV – not as standalone musical works. He even expressed his wish that they should be left unnoticed if they deserved it (Riikonen 1978, 9–11).[270] He only considered his last two works, *Ritual* (1972) and *Spectacle* (1974), his official standalone works of electronic music, even though he lists *Kinetic Forms*, *Mechanical Music for Stereophonic Tape*, *Tropicana* and *Midas* in his curriculum.[271]

Ritual was awarded first prize in the electronic and computer music category of the 1972 International Musical Composition Contest (IMCC) organized by the Italian Society of Contemporary Music (ISCM). Over one thousand works from 43 different countries were entered,[272] including 74 works in the electronic and computer music category together with Lindeman's *Ritual*. The work[273] was released in 1978 on the album *Suomalaista elektroa-*

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[269] Kurenniemi (2002) CD *Äänityksiä/recordings 1963–1973*.

[270] Lindeman (1975) in an interview with Sermilä.

[271] See FIMIC (1979), composer brochure.

[272] See Lindeman's scrapbook for the telegram announcing the news about the first prize, newspaper and magazine articles about the news; Lindeman, Osmo, Lindeman, Sirkka, & Ojanen, Mikko. (2020): http://doi.org/10.5281/zenodo.3886432

[273] The description in FENO 5 (1978): "Ritual depicts a religious event which one may understand from any religious point of view. Dominating the opening part of the work is a monotonous and litany-like speaking – a kind of mumbling suqqestive of an audience, or in this case congregation. An electronic backcloth, later rising into foreground, pictures the moods and emotional reactions of the easily impressionable congregation. It goes without saying that ritual events may take on many different forms. They can be beautiful and festive, but may also be bewildering or even offensive. In all cases the ritual serves to channel and mould the thoughts of those who participate in it.

kustista musiikkia: Finnish electro-acoustic music.[274] *Spectacle*[275], for which the main sound sources were the VCS 3 and the Minimoog, was commissioned by Yle. It comprises three parts, *Lamentation*, *Meeting* and *Epilogue*, and it was released on the album *Musica Nova Academiae: Sibelius-Akatemia 1882–1982* (Sibelius-Akatemian äänilevysarja 1, SALP 1) in 1982.

Lindeman mainly used electronic sound sources in his electronic music works. Even though *Ritual* consists of some concrete sound material such as speech, he did not employ the techniques or follow the tenets of *musique concrète*. The vocal sound for example, is fully recognizable as human speech – even if the content is intentionally meaningless. Lindeman concentrated solely on composing tape music works in his home studio because he thought his equipment was not suitable for live electronics.[276]

The DICO remained in Lindeman's home studio together with his other synthesizers including the EMS VCS 3 Mk III, the Micromoog, and several discrete oscillators and sound-processing equipment. Lindeman died in 1987, after which his home studio was dismantled. The DICO was stored for a couple of years, first in the premises of a music school in Espoo, and later in CARTES (the Center of Art and Technology in Espoo). Ruohomäki eventually stored the instrument in the cellar of the University Studio, where it was discovered in 2003 and restored, shortly after a revival of interest in Kurenniemi's instruments. Since then, the DICO has been used both in the University Studio and in live performances.

In this respect Ritual is really a sort of parody, though not such as would be intended to cause offense. It merely attempts to point out the conscious theatricality of the ritual event: a theatricality whose value to modern man may seem a little questionable. Ritual was made in my own private studio. At the present time this studio houses two different types of electronic sound synthesis equipment: a programmable digital sequence oscillator, and a group of different devices for signal generation, control and modification (oscillators, filters, modulators, echo units, mixers and metering equipment) and three stereo tape recorders. Ritual was made using considerably more modest equipment resources, however: allow sounds other that the speech sounds were derived from two oscillators, a ring modulator, filter, noise generator, echo unit and tape recorders. Ritual was awarded first prize in the electronic category of an international composition organised by the Italian section of the ISCM in 1972." (Translation from the composer's original text for the album liner notes by Dr. Andrew Bentley.)

[274] Fennica Nova, FENO 5.

[275] The description in SALP 1 (1982): "Elektroninen sävellys Spectacle valmistui Yleisradion sävellystilauksena v. 1974. Se sisältää kolme elektronista sävelrunoelmaa Lamentation, Meeting ja Epilogue. Näille osille on säveltäjä antanut seuraavat erilliset alaotsikot: Yksinäinen äänitaajuusgeneraattorin valitusvirsi ristikytkentäkentässä, Tunnelmia eräästä puoluekokouksesta, Pieni lyyrinen loppusoitto." (Engl. "The electronic composition Spectacle was completed as a commission from the Finnish Broadcasting Company in 1974. It contains three electronic poems, Lamentation, Meeting and Epilogue. The composer gave the following separate subtitles to these parts: A lamentation of a lonely frequency generator in a patch bay field, Moods from a party meeting, A small lyrical ending."

[276] Lindeman (1975) in an interview with Sermilä.

5.3 The DIMI series and Digelius Electronics Finland (DEF)

The history of Kurenniemi's company, Digelius Electronics Finland (DEF), is intertwined with the design and building of the DIMI (Digital Musical Instrument) series. Because the first DIMI was completed before the founding of the company, I present the history of Digelius only briefly as a side-track of the narrative of DIMI synthesizers. The company would need a more thorough historical presentation.

5.3.1 The first DIMIs and the foundation of DEF

In a magazine article in *Apu* published on February 5, 1971, Kurenniemi reminisces about his trip to the Florence electroacoustic music conference in June 1968. He describes how his enthusiasm for electronic musical instrument building burst from a spark into flames after the conference.[277] He had already spent a few years building the University Studio and the Integrated Synthesizer. The Sähkökvartetti and Andromatic designs existed at the time of the Florence conference, and within the forthcoming few months Kurenniemi would build the DICO for Lindeman. The starting points of the design processes for each instrument cannot be verified from current documentary evidence. Numminen recalls that he started envisioning the Sähkökvartetti in 1966[278] (Suominen 2013). According to Nilsson, over the years they had several conversations with Kurenniemi about the role of electronic musical instruments in the composition and production of electronic music – and within the art form in general.[279] Kurenniemi had a meeting with Lindeman on July 22, 1968.[280] In any case, Kurenniemi completed these three customized designs in approximately eight months between July 1968 and early 1969. He clearly gained momentum for instrument building and the intensive development work continued.

Not much is known about the early phases of the instrument that became the first DIMI (1970; see Figure 37). Later it acquired its current name, DIMI-A, A standing for the technical implementation of its memory unit – the so-called associative memory schema (Ojanen & Suominen 2005, 24–25; Lassfolk et al. 2015 266–270; see also Chapter 6.2.5) and being the first of the DIMIs. The DIMI-A was completed in the summer of 1970 – in August at the latest. Alongside the DIMI-S (1972) and the DIMI 6000 (1975) it was an exception among Kurenniemi's instruments in that two copies were produced. One DIMI-A was purchased by Lundsten and the other one remained

[277] Leino (1971, 35/*Apu* February 5, 1971).
[278] See Gronow (1966, 47)
[279] Nilsson (2019) in an interview with Ojanen; see also Lundsten (2018) in an interview with Ojanen.
[280] See Kurenniemi's daily planner 1968.

in the University Studio, even though its ownership history remains unclear, and Yle also shared in its purchase.

Figure 37. Kurenniemi programming the DIMI-A sequencer synthesizer in an unknown location (photo: unknown / The Finnish National Gallery / Erkki Kurenniemi archive)

No documentary evidence related to the instrument's development or its original schematics has survived. Ruohomäki, who was studying musicology in the University Studio at the time, recalls that when the instrument appeared it was already completed. He does not remember Kurenniemi building the DIMI-A in the Vironkatu premises.[281] It seems plausible that Kuren-

[281] Ruohomäki (2018) in an interview with Ojanen.

niemi worked on the first DIMI at the Elektromusiikki[282] premises in Kulosaari, Helsinki. Elektromusiikki was owned by Jouko Kottila, who imported and designed electronic music equipment and instruments such as home organs, spring reverb units and drum machines. It also seems plausible that Kurenniemi did not build the entire synthesizer on his own. A graphic designer at least, and some people who would become employees of Digelius when the company was established – such as Jouko Ketola and a few others – were involved in the building process, in the soldering sessions, for example.

Having finished the first DIMI, Kurenniemi applied for a loan from the Finnish Innovation Fund Sitra to develop his instruments and received a grant of FIM 84,000[283]. To get the funding he needed a fiscally responsible organ. He faced a similar situation to the one Donald Buchla, Morton Subotnick, and Ramon Sender faced a few years earlier when they eventually received funding from the Rockefeller Foundation. The San Francisco Tape Music Center had to be merged with Mills College, which "fitted the bill" (Bernstein 2008, 115).

According to Kurenniemi, the founding of Digelius Electronics Finland happened very hastily, and within hours Peter Frisk, the third partner and the CEO-to-be, along with Kurenniemi and Kottila, had registered the company at the Finnish Patent and Registration Office on September 18, 1970.[284] In 1971, Kurenniemi estimated the approximate retail price of the DIMI-A at approximately FIM 15,000.[285]

Kurenniemi's first known public appearance with the first DIMI was at Nuorison taidetapahtuma (Engl. The Youth Art Event) in Turku on October 30, 1970, where he demonstrated the instrument.[286] He and Ruohomäki introduced the DIMI-A in *Sähköinen tapahtuma Vanhalla*[287] (Engl. An Electronic Event at the Old Student House) in Vanha Ylioppilastalo, Helsinki on November 17, 1970 (see Figure 38). In December, Kurenniemi paid a visit to English synthesizer manufacturer Peter Zinovieff in his studio in London to present the DIMI-A for marketing purposes. A few notes about the trip survive on Kurenniemi's first audio tape diary c-cassette recorded December 18–20, 1971.[288] Despite the promising first contact, no DIMIs were sold to

[282] See Figure 73 in Chapter 6.2.1 depicting the printed outline of the DIMI-A user interface with hand-written markings about the material and its properties used in the plates, as well as remarks about "ELEKTROMUSIIKKI".
[283] Today approx. EUR 125,000; see the Money Value Converter: http://apps.rahamuseo.fi/rahanarvolaskin#ENG
[284] See journal number 1406/178-70; the Finnish Patent and the Registration Office. See also Leino 1971; 35–36.
[285] Today approx. EUR 20,000, Leino (1971); see also Kurenniemi (1971a.)
[286] Pitkänen (1970, 29/*HS* October 31, 1970).
[287] Lehtikuva archive pictures ID: 33197848; see also the recording in the Yle archive ID: 000053962.
[288] Kurenniemi's audio diary c-cassette C4000/R-4021.

Zinovieff. However, Kurenniemi purchased the Putney for the University Studio.[289]

Figure 38. The DIMI-A waiting its turn while Sähkökvartetti (the band) is performing *Kaukana väijyy ystäviä* at *Sähköinen tapahtuma Vanhalla* (Engl. An Electronic Event at the Old Student House) in Helsinki on November 17, 1970 (photo: Pertti Messo / Lehtikuva)[290]

[289] Leino (1971, 36/*Apu* February 5, 1971).

The second notable demonstration of the first DIMI was in the Primula cafe[291] in Helsinki, on January 20, 1971 from 12 noon until to 2 pm. Invitations to this Digelius Electronics Finland briefing were sent at least to ten journalists writing for newspapers and magazines.[292] Only a few magazine[293] and newspaper[294] articles are known of, even though the authors are not mentioned on the initial invitation list sent out by the owner of the record label Musica Pertti Lehto, which released the *Dimi-1: Dimi is born*[295] promotional single record (see Figure 39). The program at the briefing included QA by Peter Frisk, a demonstration of the DIMI-1 (i.e. DIMI-A) by Kurenniemi and Ruohomäki, the release of the promotional sound recording Dimi-1: Dimi is born and Kurenniemi's presentation of the DIMI-U and DIMI-O projects. The photo session for the article published the following day in Helsingin Sanomat was held in the University Studio at Vironkatu after the Digelius briefing[296] (see Figure 40).

The first works completed with the DIMI-A were Erkki Salmenhaara's soundtrack for the documentary film *Maan aurinko*[297] (1968/70; Engl. Sun of the Earth), *Kolme DIMI aihetta* (1970; Engl. Three DIMI themes) and *Mikä aika on* (1970; Engl. What time is) by Ruohomäki. The two-part piece *Inventio-Outventio* (1970), which was realized in the fall of 1970, consists of Kurenniemi's arrangement of Johann Sebastian Bach's Invention No. 13 in A minor (BWV 784) for the DIMI-A, and the tape collage *Outventio* realized jointly by Kurenniemi and Ruohomäki in a separate session. Kurenniemi's Bach arrangement for the DIMI-A remains the only work he composed solely with the instrument. He used the DIMI-A sounds later in his sound collages *Mix Master Universe* (1973, with Ruohomäki) and *?Death* (1972–1975), as well as in the exhibition soundscapes *Suomi rakentaa* (1970) and *Pohjoismaiset rakennuspäivät* (1971).

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[290] Lehtikuva archive ID: 33197848; Date Created: 19701117; Creator: Pertti Messo. Originally published in *Helsingin Sanomat* on November 19, 1970, see Salmenahaara (1970, 19 / *HS* November 19, 1970).

[291] At the corner of Kalevankatu and Mannerheimintie in Helsinki (personal communication with Ruohomäki on March 27, 2020).

[292] See the list of contacts in the invitation letter sent by the owner of the record label Musica Pertti Lehto.

[293] See Leino (1971, 35–36/*Apu* February 5, 1971); Kujasalo & Fröberg (1971, 67/*Suosikki* June 1, 1971).

[294] *HS* (January 21, 1971, 5; 13); *ESS* (January 21, 1971, 7); *Länsi-Savo* (January 21, 1971, 10). Written from the same news feed.

[295] Musica, DSS-1.

[296] Lehtikuva archive ID: 1316478, 1260078, 1260076; Date Created: 19710120; Creator: Matti Saves.

[297] Documentary film *Maan aurinko* in Yle's archive; Name of the program: *Maan aurinko* (Engl. Sun of the Earth). Media ID: MEDIA_2014_00768009; Program ID: PROG_2009_00105005; First aired on October 25, 1970. Director: Heikki Ritavuori.

DI[illegible]I – tiedotustilaisuus

[illegible]keskiviikkona 20.1.1971 klo 12—14 [illegible]rimala [illegible]elow [illegible]k.2C

[illegible]änil. vy:

A-puoli: Inventio-outventio ([illegible]och – [illegible] Kure[illegible]icni – Ju[illegible] Ruohom[illegible]k

B-puoli: [illegible] aika on (Ju[illegible] Ruohom[illegible]ki)

Ohjelma:

1. [illegible], [illegible] [illegible] [illegible]koiin

2 DI[illegible]I-1 esittely ([illegible] i[illegible]i, Ruohom[illegible]i)

3 [illegible]ilevyn esittely

4 DI[illegible]I-U ja DI[illegible]I-O (Kure[illegible] i[illegible]i)

1 Uusi [illegible]. T[illegible]i [illegible]hu

2 [illegible]: [illegible]

3 [illegible] ili: [illegible] 649717

4 Seura: [illegible]

5 Intro: [illegible] [illegible]ko, [illegible] [illegible], 647467

6 Suosi[illegible]: Jyrki [illegible]inen

7 [illegible]: Ulla [illegible]nen

8 Kotip[illegible]ti: [illegible] Karlsson

9 [illegible]ti:

10 Seo[illegible]:

Pertti Lehto [illegible] 11 C 33 Consillator puh. 629590

Figure 39. Invitation letter to the Digelius briefing from the owner of the Musica record company, Pertti Lehto

Figure 40. Kurenniemi and Ruohomäki performing with the DIMI-A in the 2nd Vironkatu setup of the University Studio on January 20, 1971 (photo: Matti Saves / Lehtikuva[298])

The instrument was used in several recording sessions at the University Studio during the 1970s. Apart from the Digelius promotional sound recording, *Dimi is born*, it features on the track *Sirkuksen seinillä* (Engl. On the Walls of the Circus; see Chapter 7.1.5) in the album *Sirkustirehtöörin pieni sydän* (1973; Engl. The Little Heart of the Ringmaster) released by Cumulus, a folk group with a psychedelic flavor. In addition to works published at the time, a few unpublished recordings with the instrument survive in the University Studio archive – such as a Dimi 1 improvisatory recording[299] with the date December 6, 1970 on the reel container. Ruohomäki arranged Bach's Invention No. 1 in C major (BWV 772) in the fall of 1970, and a few years later Heikki Valkonen used the DIMI-A in his arrangement of *Le Coucou* (1977) by Louis-Claude Daquin.

At the time of the first documented demonstration session with the DIMI-A in *Sähköinen tapahtuma Vanhalla* on November 17, 1970, Kurenniemi was already of the opinion that the technology used in its implementation was obsolete. Donner interviewed him by way of an introduction to the improvisation session with Ruohomäki (DIMI-A), Ilpo Mansnerus (flute), Ralf Gothoni (piano), and Teppo Hauta-aho (bass). During the interview Kurenniemi explained that a five-to-ten-times-bigger memory unit would at that time be a little cheaper than the one designed for the instrument in the

[298] Lehtikuva archive ID: 1316478; Date Created: 19710120; Creator: Matti Saves.
[299] Released retrospectively on Kurenniemi (2012): *Rules*. (Full Contact Records – KRYPT-022).

summer of 1970 – only a couple months earlier.[300] Another key shortcoming of the instrument was its cumbersome user interface, which hid the memory content of the sequencer and the state of the instrument (see also Chapter 6). The difficult real-time interaction with the instrument was aptly documented in the above-mentioned improvisation session.

New DIMI versions were already on the drawing board when the DIMI-A was being demonstrated. To overcome its shortcomings, Kurenniemi continued to develop the user interface. The next version was equipped with a video camera and monitor to enhance the readability of the memory content, and an electric organ keyboard for conventional musical instrument accessibility (see Figure 41).

According to Kurenniemi's diary entries, he came up with the suffix O for the next DIMI on January 21, 1971 after having purchased the camera and monitor.[301] The prototype was still in its infancy on February 15, but on May 10 it was in working condition (Mellais 2013[2010]). Engineer Hannu Viitasalo, who worked for Digelius from its early days and was still collaborating with Kurenniemi in the 1980s, played a significant role in the design of the instrument's video technology.[302] The initial idea behind the DIMI-O synthesizer was to use a camera to read the graphic notation and then convert it into music. Kurenniemi considered other and more interesting applications for the instrument from early on, such as using it in experimental film and TV productions and other happenings.[303] Shortly after the first version was completed, Kurenniemi, Ruohomäki, Donner and Vesterinen recorded sound material for the radio play *Vihreä eläin* (1971) based on Vesterinen's text. Donner organized the session in Yle's Fabianinkatu studio, to where the equipment was transported from the nearby University Studio, even though the only instruments (Sähkökvartetti, DIMI-A, DIMI-O) being used were from the University Studio. *Vihreä eläin* was the first Finnish electroacoustic work to win an award in an international competition.[304]

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[300] Kurenniemi (1970 / *Sähköinen tapahtuma Vanhalla*, Sound recording in the Yle archive ID: 000053962): "Kehityksen vauhti on niin ilahduttava, että jos nyt – tämä DIMIhän rakennettiin viime kesänä – ja jos nyt vaihdetaan muisti viisi tai kymmenen kertaa suuremmaksi niin sen hinta on pikkusta hiukan halvempi kuin tämä vanha sadan sanan muisti." (Engl. "The pace of development is so gratifying that if you now – this DIMI was built last summer – and if you now swap the memory for one five or ten times bigger the price would be a little cheaper than this old one-hundred-word memory.") Interestingly, Lundsten describes a 500-command memory capacity when introducing his copy of the instrument in the documentary film in 1973 (see Sima, Jonas. 1973: *Cosmic Love*).

[301] See also the Digelius briefing program, January 20, 1971.

[302] Viitasalo (2004) in an interview with Ojanen & Suominen; Viitasalo (2015) in an interview with Ojanen & Suominen.

[303] Kurenniemi (1971a).

[304] See *HS* (July 20, 1971, 25), advertising a radio program in which Donner talks about *Vihreä eläin* winning the first prize in a competition at the Prix Jean Antoine festival in Monte Carlo earlier in the summer.

Figure 41. Kurenniemi playing with and programming the DIMI-O sequencer synthesizer, January 24, 1972; in Digelius Electronics Finland premises in Luotsikatu 4. Previously unpublished photo. Two other photos from the session published in *Iltasanomat* on February 22, 1972.[305] (photo: unknown / Lehtikuva[306])

Kurenniemi's active involvement in the performances and happenings, which started in the early 1960s, continued in the 1970s. He had frequent connections with the avant-garde and underground art group Elonkorjaajat, although he was not an official member. The Elonkorjaajat gallery *Halvat huvit* (Engl. Cheap thrills) was located at Huvilakatu 12 in the Eira district of Helsinki. This was close to Kurenniemi's first workspace, in other words the premises of Digelius at Huvilakatu 24, from its foundation until early 1972.[307] Elonkorjaajat, and especially the leader of the group J. O. Mallander (b. 1944), had close contacts with the Fluxus movement and their leaders, including Nam June Paik (Eerikäinen 2007, 85).

Intermediality was one of the art concepts adopted and further developed by Fluxus. In the Finnish context the term has been strongly associated with Kurenniemi, who used the word intermedia to describe his work *Deal* (1971), which he composed for a video-controlled instrument in 1971. The first person to use the term in Finland, however, was Mallander[308] in his Iiris maga-

[305] See Pitkänen (1972, 7/*Iltasanomat* February 22, 1972).
[306] Lehtikuva archive ID: 1316483; Creator: [unknown/no photographer info in the Lehtikuva database]; Date: 19720124. See also the Lehtikuva archive IDs: 2125578, 2125579. *Iltasanomat* mentions Ari-Veikko Peltonen as the photographer in the session.
[307] See Ojanen, Mikko. (2019). *The development of Digelius Electronics Finland (DEF) in the documentary evidence* (Version 20191225_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3592770
[308] Mallander (1970, 2–4, 22/*Iiris* 8/1970).

zine a year before Kurenniemi drafted the score for *Deal*. 'Intermedia' was also the main title of the first Elonkorjaajat event at the Old Student House on May 26, 1971: this was when Kurenniemi made his first known public appearance with the DIMI-O[309] (Eerikäinen 2007, 86) (see Figure 42).

Figure 42. The DIMI-O in the Elonkorjaajat event at Vanha Ylioppilastalo on May 26, 1971 with Jaakko Vartia dancing and Kurenniemi operating the DIMI-O in shadows behind the video monitor; previously published in *Taide* magazine 6/1971 as part of Kurenniemi's article "Message is Massage"[310] (photo: unknown / the Finnish National Gallery collections, Erkki Kurenniemi archive)

With its versatile implementation potential in different art forms and in the electronic music studio, the DIMI-O was tightly linked to the topical public discussion about TV and video art. Elonkorjaajat's Intermedia event, for example, comprised a panel discussion and a presentation of the role of the video in broadcasting and in the arts.[311] Later, recorded on September 6 and 17, 1971 in the University Studio on Vironkatu, the DIMI-O was used to produce the title graphics and introductory music for the Yle educational and documentary film *Matkalla ylihuomiseen*[312] (Engl. En route to the day after tomorrow).

[309] *HS* (May 26, 1971, 18); *HS* (May 28, 1971, 16).
[310] Kurenniemi (1971b, 36–38/*Taide* 6/1971).
[311] *HS* (May 28, 1971, 16).
[312] Yli-Ojanperä (2013): https://yle.fi/aihe/artikkeli/2013/05/30/futuristisella-matkalla-ylihuomiseen-1971); see also Kurenniemi's audio diaries C4136, C4137, C4138.

Kurenniemi took the DIMI-O to Yle on September 22, 1971 to test and develop its integration into the professional television system. This pilot-testing session was also intended to produce material for the *Nordic seminar om formproblemer ved musikkproduksjon i fjernsyn* (Engl. Nordic seminar on form problems in music production in television), held in Lysebu, Oslo from September 29 to October 1, 1971. The Finnish representative at the seminar, Ilkka Oramo, presented a paper about the potential of DIMI-O implementation in TV projects. As part of his talk, he screened the three-part demonstration recorded at Yle on September 22, 1971 comprising Kurenniemi's introduction to the key features of the DIMI-O, the so-called *Dimi ballet* with dancer Riitta Vainio, and experiments with optical feedback. Later, in his diary notes, Kurenniemi referred to the demonstration session as somewhat successful, even though the test group (Kurenniemi with Yle engineers and the director of the demonstration tape Hannu Heikinheimo) did not manage to solve the problems that arose in the video synchronization. In his presentation at the seminar, Oramo described the document "as a demonstration, not as a program or a work of art". These remarks of Kurenniemi and Oramo explain why the documentary was not screened publicly or aired by Yle at the time.[313]

The DIMI-O was used frequently in front of the public before it was sold to Lundsten. Inspired by the instrument, Kurenniemi outlined his performance instructions for the intermedia composition *Deal* (1971) in October 1971.[314] These instructions were simply loose boundaries within which the material would be presented to the instrument's camera: "The substance of Deal is a set of rules to transform random (improvised) primary visual material into electronic sounds and a secondary video signal". The score for the work does not limit its implementation to the DIMI-O, and any other similar setup could be used in its performance. Within the time frame of this study, *Deal* was performed once at the Nordic Music Days in Henie-Onstad Kunstsenter, Høvikodden, Oslo on September 3, 1972.

In addition, the DIMI-O was also presented in several exhibitions, such as the first exhibition of the Dimensio art/technology group in Tampere from

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[313] The program of the Nordisk seminar and Oramo's talk (unpublished archive document in FNG/EKA); Kurenniemi's audio diaries C4136, C4137, C4138; Kurenniemi's daily planner entry on September 22, 1971: "12.15 "Studio 4"; Demonstration film *DIMI-baletti* in the Yle archive; Name of the program: DIMI-baletti. Media ID: MEDIA_2014_00760531; Program ID: PROG_2009_00206150. Created: 19710922. Producer: Hannu Heikinheimo; The three-piece demonstration including *Dimi ballet* available on Yle web pages, see Lindfors (2008): https://yle.fi/aihe/artikkeli/2008/03/18/dimi-suomalainen-syntetisaattori; Hämäläinen (1972, 35/*Tekniikan Maailma* 5/1972)

[314] The written instructions for *Deal*, first in Finnish (October 1971) and then in English (October 26, 1971), and Erik Wahlström's letter to Kurenniemi about the acceptance of the work for the Nordic Music Days (unpublished archive documents in FNG/EKA).

September 16 to October 15, 1972[315]: Kurenniemi was one of the founding members of the group (Jylhä 2002, passim). A few days later, he demonstrated the instrument with the Oulu Symphony orchestra. The rehearsals were held on October 16, 1972. Kurenniemi performed Johann Strauss II's *Blue Danube* with the orchestra on October 18, accompanied by Einojuhani Rautavaara's *Cantus Arcticus*, which was commissioned by the University of Oulu for its first doctoral degree ceremony.[316]

The Norwegian theater group Scene 7 performed Samuel Beckett's play *Act without words* in front of the DIMI-O camera in the University of Oslo's laboratory studio (see Figures 43–45). The DIMI-O was also used in psychological tests conducted at the Department of Psychology when the camera read the testees' facial gestures as they were reading Rorschach pictures. According to Sutinen:[317]

> *"[t]he experiment aimed at finding out whether expression created artificially can be reconciled with the other expressive levels of theatre, such as gestures, facial expressions, make-up etc. - - - Arild Boman of the InterMedia centre of University of Oslo saw these experiments as an opportunity to develop new communication tools for the theatre. According to him, the early experiments in virtual reality by Kurenniemi make it possible to combine different artistic expression."*

The DIMI-O was eventually sold to Lundsten's studio, where it was frequently used until the dismantling of Andromeda in spring 2014. Lundsten used it in the realization of dozens of works, including several series of *Nordisk Natursymphoni* (Engl. The Nordic Nature Symphony, 1972–), and ballet music with which the dance group toured in Finland during the early 1970s. The Finnish State Art Commission purchased the DIMI-O from Lundsten in 2014 and placed it in the University Studio (for detailed information, see Städje 2013; for a description of the DIMI-O user interface, see Chapter 6)

[315] The first Dimensio exhibition was held at the Modern Art Museum in Tampere from September 16 to October 15, 1972. For a review of the exhibition, see Valkonen (1972, 33/*HS* October 15, 1972).
[316] See Oulu Symphony Orchestra's concert program, https://doi.org/10.5281/zenodo.4290669; see also Kurenniemi's audio diary C4059; Conductor Stephen Portman envisioned the DIMI-O performance for the spring term of 1971, see *HS* (August 30, 1971, 11); see also Heikinheimo (1972, 24/*HS* October 20, 1972).
[317] Sutinen (2002).

Figures 43–45. The DIMI-O and Samuel Beckett's play *Act without words* performed in Oslo by the Scene 7 theater group (photos: screen shots from the video in the Finnish National Gallery / Erkki Kurenniemi archive)

5.3.2 Towards an integrated and modular studio system

Shortly after completing the first DIMIs Kurenniemi directed his attention to developing the customer-oriented on-demand modular systems he had envisioned on paper. If his individual instruments are considered part of a larger system, it is clear that his ideas of integrating and modularizing the different functionalities were leading themes in his designs. Both the integration of different functionalities into one larger system and the modular design were evident in the Integrated Synthesizer. From this perspective, the DIMI-O and the subsequent DIMIs could be considered interface and control-surface prototypes for a larger system.

Archive documents including his diaries,[318] a promotional description of his digital instruments[319], and marketing letters[320] show that Kurenniemi was planning an integrated, automated and modular studio system during the early 1970s – ultimately realized as the DIMI-U or DIMI-P (U standing for universal; P standing for programmable). The former was supposed to be a complete studio system, which could have been custom-compiled from different sound and processing modules according to the customer's needs (see Figure 46). The units were never realized.

[318] DIMI-päiväkirja 1971–1972 (Engl. DIMI diary 1971–1972; (unpublished archive document in FNG/EKA).
[319] Kurenniemi (1973) digital instrument description (unpublished archive document in FNG/EKA).
[320] Kurenniemi's correspondence (unpublished archive documents in FNG/EKA).

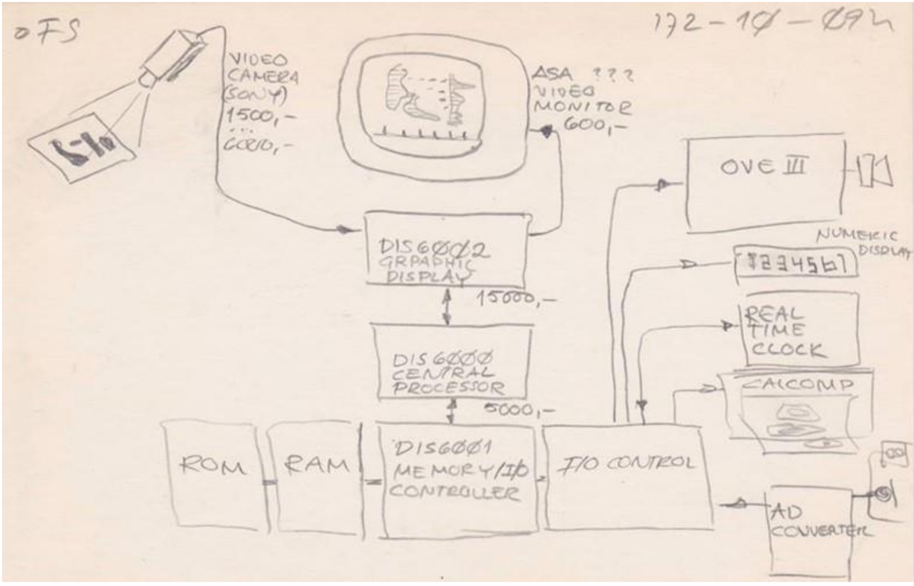

Figure 46. One of the hand-drawn sketches of the universal DIMI system the DIMI-U (1972) was supposed to be a modular custom-built system where customers could choose which modules they wanted. The sketch includes Ove III speech synthesizer, which may be related to Kurenniemi's initial plans to collaborate with the University of Helsinki Department of Phonetics located in the same building in Vironkatu together with the University Studio. (image: Kurenniemi in Erikoistietojen kortisto / the Finnish National Gallery / Erkki Kurenniemi archive)

5.3.3 Experiments directed toward a new means of instrument control

After realizing the DIMI-O, Kurenniemi went even further with his user-interface experiments to satisfy his interest in stretching the constraints associated with traditional methods of interacting with an instrument, and in finding new ways of performing music. To some extent, the inspiration for these experiments can be traced to Teatro Comunale's electroacoustic music conference in Florence in June 1968, and his collaboration with Lundsten and Nilsson. While he was at the conference Kurenniemi met American designer of electronic musical instruments Manford L. Eaton, whose ideas on biofeedback music inspired his visions of different user-interface applications. Two of his DIMIs are loosely based on the notion of biofeedback as the control signal for musical processes. (see Zaffiri 2007)

Kurenniemi's most controversial instrument was the DIMI-S[321] (1972), played by several people touching each other on the bare skin while wearing handcuffs (see Figure 47). The instrument was designed on the initiative of and in collaboration with Lundsten, who stressed that it was to be used only for fun – not as a studio instrument.[322] Lundsten presented his idea for the Kärleksmaskin (Engl. Love Machine) a year before Kurenniemi built his version of the instrument.[323] He even had to ask Kurenniemi a couple of times to build the DIMI-S before he agreed to design it.[324] When they were building the Ljudd (1968; Engl. Sound) electronic school instruments for children in 1968, Lundsten and Nilsson noticed that skin conductance could be utilized in an electronic circuit.[325] Together with Eaton's ideas, Lundsten and Nilsson's discovery served as inspiration for the design principle behind the DIMI-S.[326]

DIMI-T or the Electroencephalophone (1973), which deploys the player's EEG as a control signal for the oscillator's pitch, was similarly inspired by the notion of biofeedback as a musical control signal. The electroencephalophone was patented[327] a couple of years before Kurenniemi started to build his version. Moreover, Alvin Lucier was already using EEG as a control signal in his *Music for Solo Performer* in 1965, and Manford L. Eaton had published a similar design a few years earlier.[328]

[321] Also known as Sexophone, or Kärleksmaskin (Engl. Love Machine).
[322] Lundsten (2018) in an interview with Ojanen. For detailed information on DIMI-S see Städje (2009).
[323] See Ahlgren (1970, 7/*Svenska dagbladet* July 31, 1970); Widding (1970, 13/*Expressen* August 8, 1970)
[324] Lundsten (2018) in an interview with Ojanen.
[325] Nilsson (2019) in an interview with Ojanen.
[326] See Ahlgren (1970, 7/*Svenska dagbladet* July 31, 1970); Widding (1970, 13/*Expressen* August 8, 1970); Brandel (1971, 7/*Aftonbladet* August 1, 1971); Pitkänen (1972, 7/*Iltasanomat* February 22, 1972).
[327] See Bakerich & Scully (1973).
[328] See also Eaton (1968).

Figure 47. DIMI-S being tested by two unidentified players (presumably the secretary of Digelius on the left and Digelius engineer on the right) in Digelius Electronics Finland premises in at Luotsikatu 4, some time in 1972. In this version of the DIMI-S the handcuffs were not yet replaced with hand-held iron balls. See also three photos in *Tekniikan Maailma* 18/1972[329] from the same session. (photo: unknown / The Finnish National Gallery / Erkki Kurenniemi archive)

329 Alanko (1972, 44–45/*Tekniikan maailma* 18/1972).

Kurenniemi's biofeedback instruments were used in concert settings, although the resulting performances were demonstrations rather than serious concert performances. The DIMI-S was introduced in only a few events in Finland, as well as in magazine articles. The first version of the instrument was installed in Pripps Brewery in Sweden, where customers could perform with it. Lundsten installed another version in his Andromeda studio, where it was used in informal get-togethers with guests but not in studio work, and controlled the colored lights in the studio.

The DIMI-T was used only a couple of times in Finland. Kurenniemi tested the instrument on August 9, 1973 and documented the test session in his audio diaries.[330] It was used during a studio course in a collective performance session in the University Studio on December 10, 1973[331], and a year later in the Dimensio exhibition at Dipoli, Espoo, November 7–17, 1974. According to the user manual and the marketing information, Digelius even tried to sell the instrument.[332] No other copies are known to exist. Presumably, the instrument did not work as Kurenniemi wished, and later he rented it to Arild Boman at the University of Oslo. How it was used in Oslo is not known, according to the existing documentary evidence.

5.3.4 The DIMI 6000 and the fall of DEF

The computer-controlled synthesizer DIMI 6000 is based on Intel Micro Computer Set designs,[333] and it is connected with the founding of Yle's Experimental Studio. Again, Donner played a significant role initiating the design process. He was Head of the Yle music department in 1973, he founded the Yle Experimental Studio, and he was instrumental in ordering the DIMI 6000 from Digelius for Yle.[334] At the time, projects in Digelius were becoming microcomputer-based. In 1973, for example, intern Seppo Nikkilä discovered the Intel 8008 brochure on the Digelius shelf and discussed the implementation of the chip with Kurenniemi. Kurenniemi's diary entries reveal that he drafted the MCS-8s (Micro-Computer Set by Intel) in early 1972.[335]

The development of the DIMI 6000 started as a commission from Yle in 1974. Kurenniemi delivered the finished instrument to the Experimental Studio in April 1975 and organized a one-month course on its use.[336] Lundsten also ordered the instrument for the Andromeda studio some time in the mid-1970s. It and the ADDS terminal used to program the computer

[330] See Kurenniemi's audio diary C4113 in FNG/EKA.
[331] See the Music Finland sound archive CD5261.
[332] See Figures 77 and 78 – published in Kuljuntausta (2002 appendix).
[333] See: https://en.wikichip.org/wiki/intel/mcs-8
[334] See Sirén (1983) in *Eksessi* – the professional newsletter of the Yle Experimental studio; see also Sirén (1976).
[335] Nikkilä (2017) in an interview with Ojanen; see also Nikkilä (1993a; 1993b); see also Kurenniemi's DIMI diary in The Finnish National Gallery collections, Erkki Kurenniemi archive.
[336] See Sirén (1976).

are visible in contemporary pictures taken of the Andromeda during the 1970s, and one mounted DIMI 6000 rack unit remained in the studio instrument rack until the studio was dismantled in 2014. However, Lundsten hardly ever used the instrument (Ojanen & Suominen 2005, 31).

Ruohomäki was hired by Yle on occasions to write software for the instrument (see Figure 48). In his view, the Intel 8008 was too slow to process musical data, thus it was used rarely, and only in a few works mainly as a sound source. It would be interesting to know why it was not updated with next-generation processors such as Intel 8080. DEF intern Pekka Hoikkala, for example, recalls that he used the faster 8080 for the DISLOG: the logger system developed for the University of Oulu's mechanical technology laboratory, which he was hired to realize. Hoikkala completed the project in the spring of 1976 only a few weeks before Kurenniemi declared Digelius bankrupt.[337]

Figure 48. Ruohomäki programming the DIMI 6000 in the Yle Ratakatu studio (photo: unknown / Pekka Sirén archive)

Eventually, the DIMI 6000 was used by Pekka Sirén (1946–2019) in *Ailahtelua* (1976), Kari Keskinen in *DNA*[338] (1976–77), Ruohomäki in *Ennen iltaa* (1977), and Andrew Bentley (b. 1952) in *Bowing* (1978). Composer Joe

[337] Rautee & Hoikkala (2017) in an interview with Ojanen.
[338] Assisted by Åke Andersson; see Ruohomäki's notes on the work.

Davidow, who briefly tested the instrument (see Figure 49) and used it in *Accompanying Composition Accompanied by ...*[339] (1976), did not find it useful. He preferred Yle's Synclavier as an instrument for his electronic expressions.[340] Bentley also found that the sound of the instrument was not suitable for his needs. As he recalled in 2019, the key resources were focused on hardware development, hence the more important software development was not allocated enough time or money.[341] Composers and sound technicians Åke Andersson and Antero Honkanen remember the DIMI 6000, too. Andersson said that he did not use it in his works even though he took the course organized by Digelius upon delivery of the instrument to Yle.[342]

Figure 49. Pekka Sirén (left) assists Joe Davidow (right at the ADDS terminal) with the DIMI 6000 for his work *Accompanying Composition Accompanied by ...* (1976) in the Yle Ratakatu Studio in 1976. (photo: unknown / Pekka Sirén archive)

Given its current dysfunctional condition, information about the functionalities and sonic possibilities of the DIMI 6000 is sparse. Analyses based solely on musical works composed with the instrument catch only one side of the story. Moreover, in many cases its detection and recognition among many

[339] Assisted by Pekka Sirén; see Ruohomäki's notes on the work.
[340] Davidow (2019) in an interview with Ojanen.
[341] Bentley (2019) in an interview with Ojanen.
[342] Andersson & Honkanen (2018) in an interview with Kuljuntausta.

sound sources are questionable. Davidow, for example, could not remember precisely in which works he used the instrument.[343] Bentley, on the other hand, recalls its sound very well.[344]

Among the job announcements in newspapers such as *Helsingin Sanomat* (see Figures 50 and 51) were notifications placed by Digelius about open positions and staff needs at Helsinki University of Technology in Otaniemi. Seppo Nikkilä, Risto Rautee, and Pekka Hoikkala, among others, noticed the advertisements for technical students and contacted Digelius.[345] Seppo Nikkilä does not remember being aware of any artistic projects or musical instrument design when he was working for DEF. According to Digelius' 1974 balance statement and annual report, the representative of SITRA was of the opinion that the original purpose of the work that was funded by the loan had not been realized, and that Digelius should therefore refund it: 10 percent of the loan was paid back to SITRA in 1974.[346]

Eventually, Kurenniemi's musical instrument design assumed a minor role in Digelius, as the focus of the company shifted to the implementation of and related consultation on large industrial technology projects – such as the train scaling system developed by Risto Rautee for the large-scale metal industry company Rautaruukki[347], and the DISLOG logger system developed by Hoikkala, among several other projects. Rautee and Hoikkala worked for Digelius until its bankruptcy. As they recalled, the bankruptcy was attributable to poor financial and project management. A major part of the capital was invested in the expertise of the staff. Large projects were negotiated with the customer, and only after signing the agreement did DEF hire the staff to realize the project. The company could not charge customers in advance, and due to project delays income collapsed even though there were enough orders.[348]

DEF was still hiring personnel in January 1976: a planning engineer (Finn. suunnnitteluinsinööri), a software engineer (Finn. ohjelmistosuunnittelija), and assembly workers (Finn. kokoonpanijoita; see Figure 51). According to the minutes of company meetings and announcements deposited in the National Archives of Finland, Kurenniemi took charge of the company on March 17, 1976 when Peter Frisk sold him his shares: Kurenniemi declared DEF bankrupt on May 18.[349]

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343 Davidow (2019) in an interview with Ojanen.
344 Personal communication with Andrew Bentley.
345 See Nikkilä (2017) in an interview with Ojanen; see also Rautee and Hoikkala (2017) in an interview with Ojanen.
346 See the DEF balance sheet and annual report in Jouko Kottila's papers in the UHMRL archive.
347 Rautee, Risto, 1978. *Junavaa'an tietojenkäsittelyjärjestelmä* [Train scaling data processing system]. M.Sci (Tech) thesis. Teknillinen korkeakoulu, Otaniemi.
http://doi.org/10.5281/zenodo.3592770.
348 Rautee & Hoikkala (2017) in an interview with Ojanen.
349 On the development of DEF in documentary evidence see: Ojanen, Mikko. (2019): *The development of Digelius Electronics Finland (DEF) in documentary evidence* (Version 20191225_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3592770.

Suomen pienin, ekspansiivisin, teknologiaa pursuvin elektroniikkayritys hakee

MYYNTIMIESTÄ

Yrityksemme on Suomessa yksi harvoja joka pystyy rakentamaan ja rakentaa tietokoneita. Mielestamme meilla on Suomen paras digitaaliteknologia, sanokoot kilpailijamme mita tahansa. Suunnittelemme ja rakennamme prototyyppejä, markkinoimme valmiita tuotteita yli koko maailman, seka tuomme maahan korkeatasoista elektroniikkaa, teleprinttereitä, puolijohteita, sähkömekaanisia komponentteja, ydinmuisteja sekä muita alan tuotteita.
Myyntimiehen tehtavä on toimitusjohtajan ja hallinnollisen johtajan johdolla rakentaa sita markkinointiprofiilia, joka on yrityksemme kehityksen aikana muokkautunut ajatuksissamme.
Myyntimiehen toimintana tulee olemaan edustamiemme tuotteiden markkinointi. Haemme teknisen ja kaupallisen koulutuksen saanutta itsenäiseen toimintaan tottunutta, nuorta, ennakkoluulotonta henkilöä
Kirjalliset vastaukset pyydamme lahettämään ennen 10. 10. 1971 osoitteella

Digelius Electronics Finland Oy
Huvilakatu 24 00150 Helsinki 15

HS (October 3, 1971, 56)

Digelius Electronics Finland Oy tarvitsee

SIHTEERI-KONTTORISTIN

Digelius on nuori elektroniikka-alan yritys, jossa valmistetaan erikoista elektroniikkaa ja tuodaan maahan muuta passelia osaa. Yrityksessä työskentelee melko ahkerasti 14 henkilöä. Tarvitsemme yhden lisää hoitamaan yrityksen päiväkirjaa, laskutusta, muita konttoritoimia, sekä ennen kaikkea kirjeenvaihtoa joka tapahtuu englanninkielisenä. Työajasta sekä palkasta sovitaan.
Arvoisat vastaajat pyydetään postittamaan henkilötiedot osoitteella Luotsikatu 4, Helsinki 16 tai soittamaan puh. 669039 Cederqvist 24. 12. mennessä.

HS (December 12, 1972, 32)

DIGELIUS ELECTRONICS laajentaa.

Yhtiömme pyrkii palvelemaan Suomen elektroniikkateollisuuden tuotekehittelyä asettamalla sen käyttöön suunnittelukapasiteettia. Tuomme myös maahan ja markkinoimme tietojenkäsittelyn systeemikomponentteja, instrumentteja sekä komponentteja.

Haluamme vahvistaa yhtiötämme laajentamalla henkilökuntaamme.

Haemme

HARDWARESUUNNITTELIJAA
SYSTEEMISUUNNITTELIJAA
LOGIIKKASUUNNITTELIJAA
PRINTTISUUNNITTELIJAA
SOFTWARESUUNNITTELIJAA
SYSTEEMISUUNNITTELIJAA
OHJELMOIJAA

Tarvittaessa lisätietoja puh. 90 - 669 039.
Hakemukset pyydämme lähettämään 1. 6. 1973 mennessä osoitteella:

Digelius Electronics Finland Oy
Luotsikatu 4, 00160 Helsinki 16

HS (May 23,1973, 32)

Avoimia työpaikkoja

Elektroniikka-alan alihankkija

Digelius Electronics Finland Oy on kolmen vuoden aikana kehittynyt pienestä protopajasta laadullisesti varteenotettavaksi know-hown, suunnittelutyön, komponenttien ja systeemien alihankkijaksi ja toimittajaksi.

SUUNNITTELUTYÖ
Olemme kolmen vuoden aikana suunnitelleet monta erilaista digitaali- ja analogiajärjestelmää ja laitetta; kuten esim. SSI-MSI mikroprosessori, MSI-LSI mikroprosessori, nelikanavainen video-muistimonitorointilaite EKG-kayttöön, aanen- ja signaalinkäsittelyjärjestelmät.

Palvelemme asiakkaitamme suunnittelu- ja konsulttisopimusten puitteissa, toteutamme prototyyppeja ja huolehdimme nollasarjan rakentamisesta ynnä laitteen saattamisesta sarjatuotantoon, asiakkaalla ja/tai alihankkijalla.

Olemme etupäässä toimineet Suomen elektroniikkateollisuuden alihankkijana, mutta tähdennämme kasvavaa rooliamme konepaja- ja valmistavan teollisuuden alihankkijana ja tuotekehittelijänä.

SYSTEEMIMYYNTI
Markkinoimme mini- ja mikrotietokonepohjaisia tietokonejärjestelmiä ja softwarea sekä järjestelmään ja sovellutukseen liittyvänä osana että suurtietokoneella ajettavana osituskäyttö- tai eräajopakettina.

Kokemuksemme eri tietokoneiden ja periferialaitteiden välisistä liitännöistä on huomattava. Toteutamme näitä myös erillisinä toteutuksina.

Edustamme näyttö- ja kirjoitinpäätteitä, kasetti-, termokirjoitin-, lippukirjoitin ja periferiayksiköitä.

HAEMME
kahta hardwaresuunnittelijaa toimimaan eri kehittelyprojekteissamme. Edellytämme hakijoilta kokemusta korkeasti integroidun digitaalielektroniikan suunnittelussa.
Softwaresuunnittelijaa osallistumaan DIS SYSTEM mikrotietokonejärjestelmän systeemiohjelmointiin seka muihin vaativiin ohjelmointitehtäviin.
Vastaukset pyydetaan lahettamaan osoitteella

Digelius Electronics Finland Oy
Luotsikatu 4 00160 Helsinki 16
Lisatietoja antaa toim.joht. Peter Frisk, puh. 669 039.

HS (November 11, 1973, 34)

Figure 50. Digelius Electronics Finland job announcements in *Helsingin Sanomat*, 1971–1973

Digelius

DIGELIUS ELECTRONICS FINLAND OY on kohta nelja vuotta kestaneen toimintansa aikana kehittynyt pienesta protopajasta huomattavaksi know-hown, suunnittelutyon, kotimaisten laitteistojen ja komponenttien toimittajaksi.

Toimintamme on tuottavaa ja olemme pystyneet rakentamaan yhtiomme kasvun lahes taysin omien henkisten etta taloudellisten resurssien varaan. Lahdemme lahiaikoina markkinoimaan suomalaista tietokonealan know-how'ta ulkomaille hyvin tietoisina tehtavan vaikeudesta.

Haemme kotimaisia projekteja varten
projektipäälliköitä:

1. **Digitaali-analogia-systeemikomponenttien suunnittelija**
Vastuualue laajakantoisen tuotekehittelyprojektin toteuttaminen

2. **Digitaali-systeemikomponenttien suunnittelija**
Vastuualue kotimaisten tietokonemodulien kehittaminen ja saattaminen tuotantoon

Yhtiomme markkinointipolitiikka on tahan asti maaratietoisesti keskittymalla keskeisiin kauaskantoisiin potentiaaleihin pystynyt luomaan meille lahes johtavan know-hown toimittajan maineen. Tiedamme jatkossa pystyvamme samaan, naemme taman edellytyksena menestyksekkaalle toiminnan laajentamiselle.

Jos olet niita suomalaisia suunnittelijoita jotka haluavat olla mukana luomassa kansainvalisesti kaypaa insinooritaitoa, soita toim. joht. Peter Friskille, puh. 650 955

Digelius Electronics Finland Oy
Luotsikatu 6
00160 Helsinki 16

HS (June 9, 1974, 59)

Palvelukseen halutaan

Digelius

DIGELIUS ELECTRONICS FINLAND OY on neljä vuotta kestäneen toimintansa aikana kehittynyt pienestä protopajasta huomattavaksi know-hown, suunnittelutyön, kotimaisten laitteistojen ja komponenttien toimittajaksi. Rakennamme asemaa itsellemme kotimaisena tietokonejärjestelmien valmistajana.

Toimintamme on tuottavaa ja olemme pystyneet rakentamaan yhtiömme kasvun lähes täysin omien henkisten ja taloudellisten resurssien varaan. Olemme lähteneet markkinoimaan suomalaista tieokonealan know-how'ta ulkomaille hyvin tietoisina tehtävän vaikeudesta.

Haemme kotimaisia projekteja varten
1. Laitteistosuunnitteluinsinööriä
Vastuualue: tietokonemodulien kehittäminen ja saattaminen tuotantoon

2. Ohjelmistosuunnittelijaa
Vastuualue: Software-Management-System. SMS:n puitteissa toteuttaa reaaliaikaisissa järjestelmissämme toimivia ohjelmamoduleja. Emme välttämättä edellytä hakijalta vastaavaa kokemusta.

Haemme:
Kirjeenvaihtajaa
Vastuualue: Ulkomaan ja kotimaan kirjeenvaihto ynnä sihteerin tehtäviä.

Yhtiömme markkinointipolitiikka on tähän asti määrätietoisesti keskittymällä keskeisiin kauaskantoisiin potentiaaleihin pystynyt luomaan meille lähes johtavan know-hown toimittajan maineen. Tiedämme jatkossa pystyvämme samaan; näemme tämän edellytyksenä menestyksekkäälle toiminnan laajentamiselle.

Jos olet niitä suomalaisia henkilöitä, jotka haluavat olla mukana luomassa kansainvälisesti käypää insinööritaitoa, soita toim. joht Peter Friskille, puh 650955.

Digelius Electronics Finland Oy
Luotsikatu 6
00160 Helsinki 16

HS (December 22, 1974,39)

Digelius

DIGELIUS ELECTRONICS FINLAND OY on kohta viisi vuotta kestäneen toimintansa aikana kehittynyt pienestä protopajasta huomattavaksi know-hown, suunnittelutyön, kotimaisten laitteistojen ja komponenttien toimittajaksi.

Yhtiömme on tänä päivänä johtava kotimaisten pientietokonejärjestelmien kehittäjä ja valmistaja. Toiminta on tuottavaa ja olemme pystyneet rakentamaan yhtiömme kasvun lähes täysin omien henkisten ja taloudellisten resurssien varaan. Olemme menestyksekkäästi aloittaneet suomalaisen tietokonealan know-hown markkinoinnin ulkomaille.

Haemme kotimaisia ja ulkomaisia projekteja varten:

1. Digitaali-analogia-systeemikomponenttien suunnittelijaa
Tehtävä: Kotimaisten tietokonemodulien kehittäminen (piiriteknisten ratkaisujen toteuttaminen) ja saattaminen tuotantoon.

2. Piirilevyjen suunnittelijaa
Tehtävä: Vaativien piiriratkaisujen pohjalta toteuttaa piirilevyjen lay-out-suunnitelmat.

3. Yksikkö- ja järjestelmäkoestajaa
Tehtävä: Tuotannon loppupäässä tapahtuvan testauksen ja järjestelmäintegroinnin suorittaminen.

4. Ohjelmiston suunnittelijaa
Tehtävä: Toteuttaa sekä systeemiohjelmoinnin että vaativan sovellutusohjelmoinnin tehtäviä.

5. Dokumentoijaa
Tehtävä: Vastata laajan tuotekehittelymme uusien laitemodulien dokumentoinnista.

Olemme lyhyessä ajassa kehittyneet johtavaksi insinööritoimistoksi. Nyt olemme käynnistämässä sarjatuotannon, jonka on pystyttävä tuottamaan laitemoduleja kansainvälisesti kilpailukykyisellä tavalla.

Haemme tuotantoprosessin kehittämistä ja laadunvalvontaohjelman laatimista varten:

6. Tuotantopäällikköä
Tehtävä: Nykyisen tuotekehittelyn tuotteiden saattaminen sarjatuotantoon ja tuotantolinjan kehittäminen sekä tuotannon laadunvalvontaohjelman luominen.

Yhtiömme markkinointipolitiikka on tähän asti määrätietoisesti keskittymällä keskeisiin kauaskantoisiin potentiaaleihin pystynyt luomaan meille lähes johtavan know-hown toimittajan maineen. Tiedämme jatkossa pystyvämme samaan: näemme tämän edellytyksenä menestyksekkäälle toiminnan laajentamiselle.

Jos olet niitä suomalaisia kykyjä, jotka haluavat olla mukana luomassa kansainvälisesti käypää insinööritaitoa, soita toim.joht. Peter Friskille tai suunn. pääll. Esa Tormälle, puh. 650955.

Digelius Electronics Finland Oy
Luotsikatu 6
00160 Helsinki 16

HS (June 8, 1975, 56)

Digelius

Nyt haemme
1. Suunnitteluinsinööriä

Pääasiallinen vastuualue tulee olemaan erilaisten laitemodulien kehittäminen yhtiömme DIS-mikroprosessorijärjestelmään. Työ on projektiluontoista ja vaatii pitkäjännitteisyyttä ja yhteistyöhalukkuutta. Digitaalitekniikan tuntemus välttamätön, kokemus mikroista on eduksi.

2. Ohjelmisto-suunnittelijaa

Tehtävänä on lähinnä kehittää reaaliaikaisia yleiskäyttöisiä ohjelmapaketteja erilaisiin mini- ja mikrotietokoneympäristöihin. Assembler-kielen tuntemus on välttämätön, mutta emme edellytä aikaisempaa käytannön ohjelmointikokemusta.

3. Kokoonpanijoita

Tuotantomme tarvitsee ripeitä naispuolisia kokoonpanijoita. Työ on monipuolista piensarjatuotantoa ja käsittää erilaisten elektroniikkakorttien kokoonpanoa. Normaali yksivuorotyö.

Jos tunnet olevasi hakemamme henkilö, soita suunn. päällikkö Jääskeläinen tai DI Aspola, puh. 673544

Digelius Electronics Finland Oy
Nahkahousuntie 5 3 krs
00210 Helsinki 21

HS (January 25, 1976, 53)

Figure 51. Digelius Electronics Finland job announcements in *Helsingin Sanomat*, 1974–1976

6 USER INTERFACES OF KURENNIEMI’S ELECTRONIC MUSICAL INSTRUMENTS

The technology behind Kurenniemi’s instruments is described in detail in previously published articles (see Ojanen & Suominen 2005; Ojanen et al. 2007; Städje 2009; 2012; 2013; Suominen 2013; Lassfolk et al. 2014; 2015). Media artist Jari Suominen has made a particularly significant contribution to the research on Kurenniemi in his analysis of the technical details of the instruments during his exhaustive restoration projects (see e.g. the analysis of the technical details of the DICO and the DIMI-A in Lassfolk et al. 2015, 263–269). The descriptions and material are presented in the online portal dedicated to Kurenniemi’s instruments.[350] In this chapter I summarize the key features of the instruments to facilitate the reading of the user-story analyses in Chapter 7. I start by giving a general overview of Kurenniemi’s designs, after which I present the key features of his instruments and use dimension space plots in their visualization.[351]

6.1 A general overview of Kurenniemi’s instrument design

As I note in the historical description in Chapter 5, Kurenniemi was not alone with his design ideas, even though in the main he built his instruments by himself. Envisioning the musical instrument of the future was a common topic for deliberation at the time. Kurenniemi used what he learned from the contemporary literature on electronics in his designs, as well as ideas presented in seminars and meetings. Each one of his instruments was initiated or developed in collaboration with his associates – some closer, some more distant.[352] When one looks back, one sees that his building and design processes constitute a continuous and ambitious project of assessing the potential of various music-technology applications.[353] Several overarching themes ran through his designs during the 15 years he was actively working on developing music technology.

[350] See: http://ekis.helsinki.fi.
[351] See: Ojanen, Mikko. (2019). *The User Interface and Functionality Charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* [Data set]. Zenodo. https://doi.org/10.5281/zenodo.3596466
[352] Kurenniemi (1993b) in an interview with Ruohomäki.
[353] See Kurenniemi (1971a).

First, Kurenniemi developed different applications for *automating the musical process*. Therefore, the *programmability* of the instrument was a significant thread in his designs. The functionality manifested in his sequencers and memory units, first physically and eventually in a virtual form. According to Pinch,[354] Robert Moog`s designs dominated historical descriptions of early analog performance synthesizers because the story is typically written from the perspective of instruments used to perform music in a traditional manner. In other words, the musician typically performs the note-based musical expressions in the context of Western (popular) music. The description would be very different if the narrative concentrated on the development of musical sequencers, however: Donald Buchla's designs would have ruled over those of Moog, for example. This line of thought reveals an exceptional feature of Kurenniemi's instruments – his sequencers. As Jari Suominen[355] noticed when he was restoring the Integrated Synthesizer, which included Kurenniemi's first known sequencer, Kurenniemi's design preceded Buchla's by several months.

Second, a strong thread in Kurenniemi's design was the implementation of *digital electronics* in sound synthesis and processing, and in sequencer and memory applications. Here in particular, his work with memory applications distinguished his instruments from many others under design at the time. According to Pinch & Trocco (2002a, 120–121), users of Moog's modular synthesizer in the late 1960s could not "go back" to the previous sound when they were programming the instrument with physical patching cords and without any memory units. The memory units in Kurenniemi's instruments helped to overcome the problem but did not solve it entirely. On the other hand, compared to the RCA synthesizer, which could be precisely programmed, Kurenniemi's design allowed real-time control whereas the RCA synthesizer was not capable of real-time modification of the memory content.

Third, Kurenniemi's *interface design* challenged the traditional means of interacting with a musical instrument – in some cases not only between the composer or performer and the instrument, but also with the audience. Closely related to his experimentation with the user interface and methods of instrument control, and despite the minor role of these themes, Kurenniemi paid close attention to *usability issues* and even *graphic design* (see e.g. the "DIMI is born" poster marketing DIMI-A: the font set is the same as in the digital patch bay and mixer DIMIX, as well as in the Digelius Electronics Finland logo).

Fourth, throughout his designs he aimed at *collective music making and performing*, and he planned to distribute musical signal processing and composition over the network, even to people's homes (Zaffiri 2007).

[354] Alternative Histories of Electronic Music (AHEM) conference keynote lecture on April 15, 2016, The Science Museum Dana Research Centre, Queen's Gate, London.
[355] Personal communication with Suominen; see also Suominen (2020).

6.2 The key features of Kurenniemi's musical instruments

Here I describe the key features of Kurenniemi's instruments in more detail, using dimension-space visualization as a methodological tool (see also Chapter 3.2). I concentrate on his nine musical instruments and leave the studio equipment (such as the digital patch bay and DIMIX mixer) aside. I depict the features related to the usability of the instruments that I consider relevant (*the pertinences*), and necessary to complement the user stories. I present the features as dimension space axes, which I group together here according to their targets (see Figure 52).

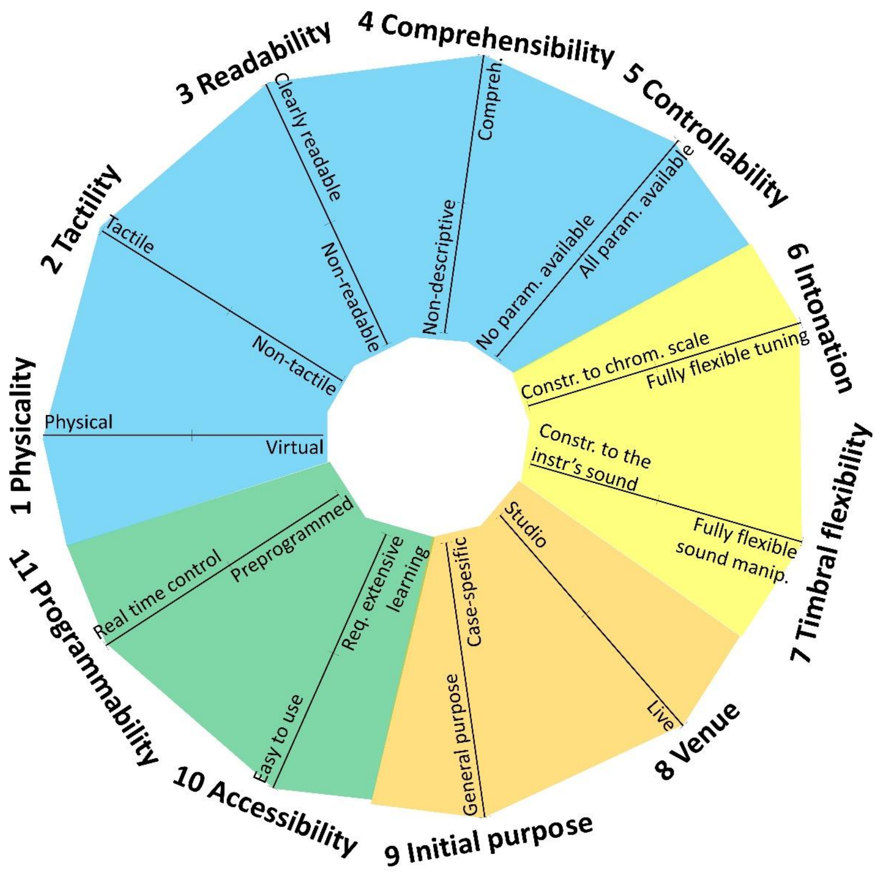
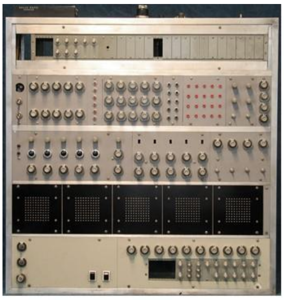


Figure 52. Key features of the user interfaces and functionalities of Kurenniemi's electronic musical instruments categorized in four groups outlining the user-interface details, the sound quality and flexibility of the instrument, the designer's initial ideas for its intended use and the user's view of its playability (figure: Ojanen 2019)

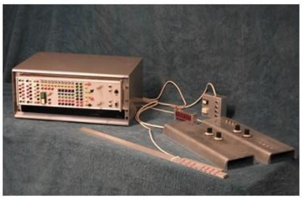
Axes 1 to 5 cover features related to the user interfaces. The first two describe the nature of the interface, which may be physical, virtual, or both, and tactile, partially tactile or non-tactile. The third and fourth axes break down the readability and comprehensibility of the user interface. It may, for example, be clearly readable in the sense that the user can see the state of the instrument but may not be able to comprehend what it means or how the instrument would sound in that state. In this case, the user has to verify the sonic output with audible feedback from the instrument. The combination of non-readable and fully comprehensible features would be an oxymoron, however. The fifth axis shows whether the user has access to all the parameters of the instruments or only to some of them, or no access to any controls.

The next two axes (6 and 7) relate to the role and flexibility of the sonic output of the instrument, in other words control options related to the music's theoretical content – both pitch and timbre. Axes 8 and 9 concern the designer's initial ideas about where the instrument was intended to be used – whether in a studio or in a live setting, and whether it was designed to be a case-specific or a general-purpose device. The final two axes (10 and 11) relate to playability issues, which are close to the first five axes – completing the user-interface descriptions from the user's point of view. The tenth one is loosely related to the learning curve (see e.g. Jordà 2004, 331–332), and the eleventh concerns the programmability of the instrument.

In the following I use the categorization to map and compare the instruments, and to depict the developmental lines in Kurenniemi's design process. For the general overview I first gather together the instrument user interfaces (see Figures 53–61) and their corresponding key features, charted by means of dimension space visualizations (see Figures 62–70).

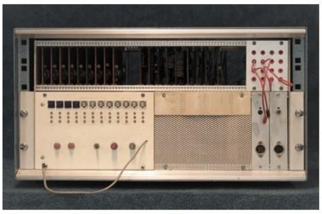


Integrated synthesizer
(1964)

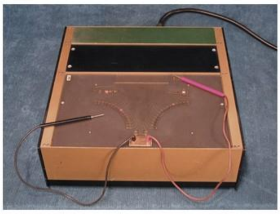


Electric Quartet
(1968)

Andromatic
(1968)

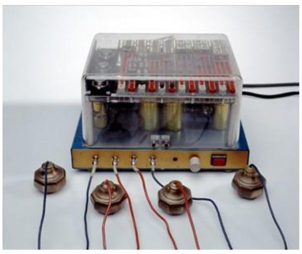


DICO
(1969)



DIMI-A
(1970)

DIMI-O
(1971)

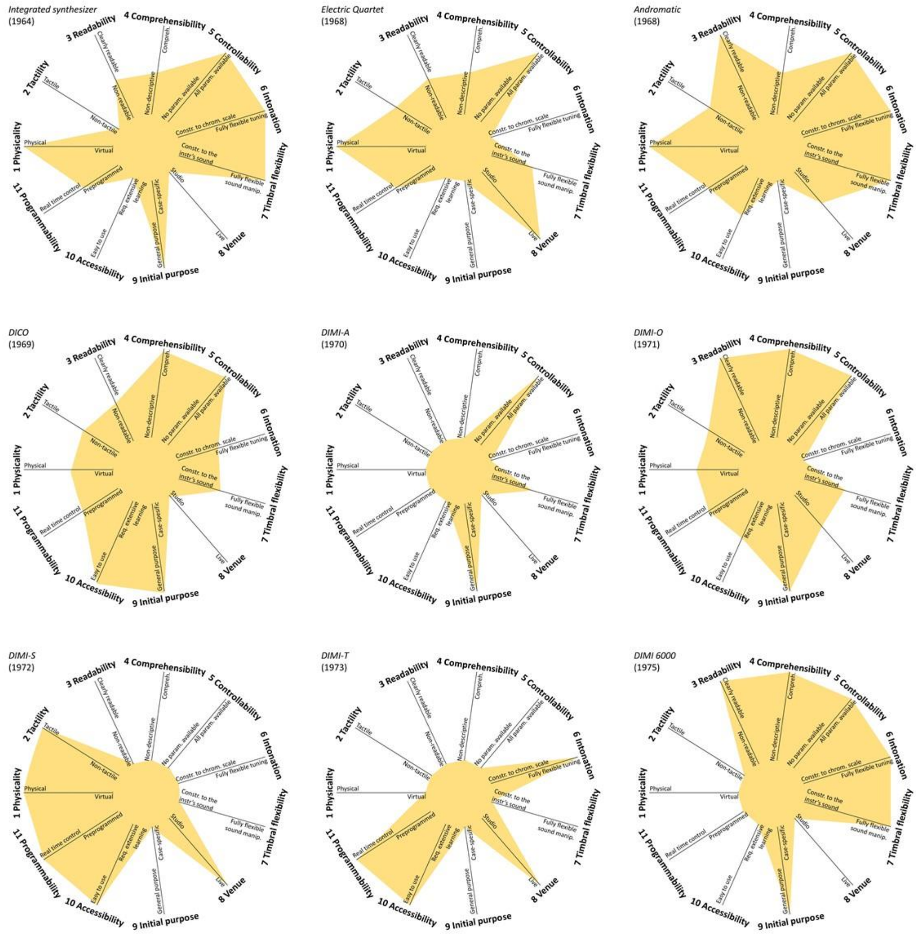


DIMI-S
(1972)

DIMI-T
(1973)

DIMI 6000
(1975)

Figures 53–61. The key features of Kurenniemi's electronic musical instruments: the user interfaces. NB! The scale of the images varies: the Integrated Synthesizer control panel is approx. 1x1 meter whereas the control panels of most of the other instruments occupy the width of a studio rack unit, that is approx. 50 cm. (photos: Mikko Ojanen & Jari Suominen 2004; Rastas/Kiasma 2007; Jari Lehtinen; DEF 1972)



Figures 62–70. The key features of Kurenniemi's electronic musical instruments: the dimension space visualizations[356] (figures: Mikko Ojanen 2019)

[356] See: Ojanen, Mikko. (2019). *The User Interface and Functionality Charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* [Data set]. Zenodo. https://doi.org/10.5281/zenodo.3596466

6.2.1 Short descriptions of the user interfaces

In the following I refer to the figures on the previous pages 160–161.

The *Integrated Synthesizer* consists of several modules, including a five-step sequencer, individual oscillators, a harmony generator (with a four-tone generator), a cluster generator (ten voltage-controlled oscillators), and a summing mixer (see Figure 53, top row, left). Oscillators and generators are assignable to the sequencer via rotary switches and their signal can be processed by assigning them to digital logic modules via five 10x10-patch matrixes. The length of each step of the sequencer can be adjusted individually. The system is implemented as a hybrid design of digital and analog electronics. (see Suominen 2013, 134–135; 2020)

The *Sähkökvartetti* consists of a mainframe and six mobile controllers (see Figure 54, top row, center). The mainframe includes a sound generator and processing units for each member of the quartet: electric drums, a melody machine, electric saxophone, and electric violin (the violin controller has vanished and is not shown in the photo), as well as the signal processor for a singer consisting mainly of different distortion channels. In practice, four synthesizers, a sound-processing unit and digital trigger signal-outputting sequencer are integrated into the mainframe (Suominen 2013, 135–139). The discrete instruments can be played both via the remote controllers and by assigning their parameters to the 10-step sequencer with patch cables in the mainframe. The overall tempo of the sequencer can be adjusted, but not the length of each individual step. The connections make it possible to perform with the instrument, the output of which is thus a combination of actions by four players and the programmed sequencer. The interconnected signal processing between the players is mainly filtering and ring modulation. The set-up establishes chaotic premises for the collective performance, whereas the user interface and the sequencer set the constraints that direct the overall performance process. The distorted output signal with a narrow frequency response emphasized on a nasal band, and the unstable tuning of oscillators characterize the distinctively provocative character of the instrument.

The *Andromatic* is a 10-step polyphonic sequencer synthesizer, each of the ten steps having its own oscillator (see Figure 55, top row, right). Three potentiometers on each step control the pitch, volume and holding of the note. The player can use the flip-flop switches on the bottom row to set a function at each step. In the basic shift register mode, the flip-flop passes the sequence to the next step. When all the flip-flops are in this position the instrument plays a ten-step sequence. In another mode the flip-flop stops the sequence while the third position sets a step to function as a counter, which acts as a divider. When all the steps are in the counter mode, the instrument plays a 1024 ($=2^{10}$)-step long sequence. (Städje 2012; Suominen 2013) The 10x10-patch matrix allows the signal to be routed into different filter banks. Using the potentiometers on the far-right, the user can alter the filter parameters and control the modulation, vibrato, overall tuning and tempo of the sequencer. The memory of the instrument is reflected in the positions of the switches and knobs. Thus, the state of the instrument is fully visible to its user and each parameter is easily accessed.

The *DICO* is a 12-step monophonic sequencer synthesizer with two output channels (see Figure 56, middle row, left). Ten lights on the front panel display the state of one sequencer step at a time. On each step, the instrument's four parameters can be programmed with ten bits by grounding the pins: the upper pin turns the bit on, and the lower pin turns it off (see Figure 71). The grounding can be done with a metal brush or by connecting the upper or lower pins with the middle pin. Reading from left to right, the first four bits control the chromatic pitch of the step (24=16 pitches), the following three control the octave range (23=8 octaves), and the next two control the articulation of the note on the step from fully legato to staccato when the sequencer is running (22=4 note lengths). The last bit assigns the sound to one of the two output channels (21=2 channels). The two potentiometers control the tempo of the sequencer and the overall pitch of the oscillator. The length of the individual steps cannot be adjusted. The push buttons control the manual stepping, and the starting and stopping of the sequencer. The 4x4 patch matrix in the upper-left corner of the user interface contains the filter and the attenuator bank. An external signal can also be fed through the filter and the attenuator bank via the patch matrix.

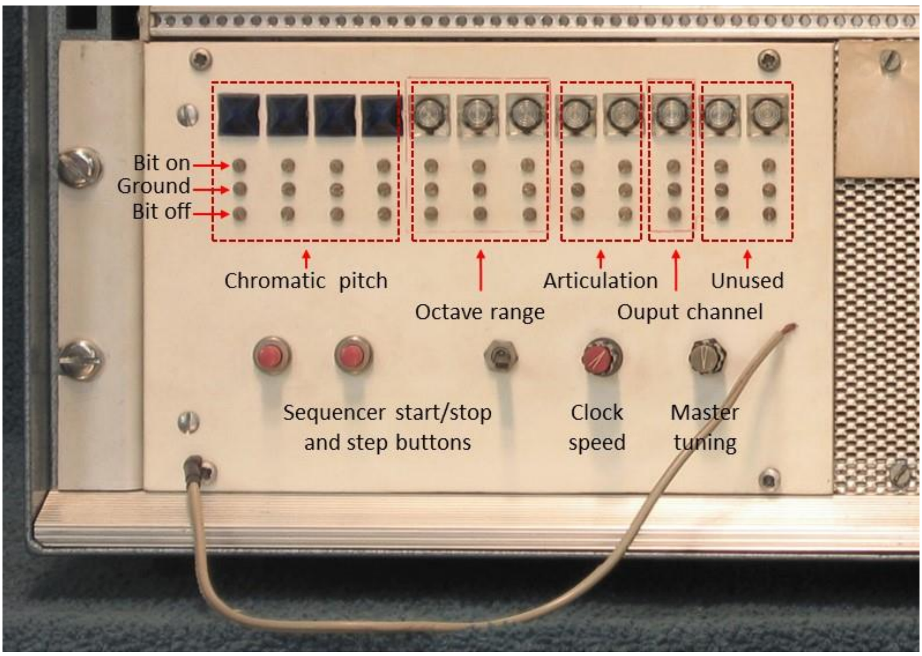
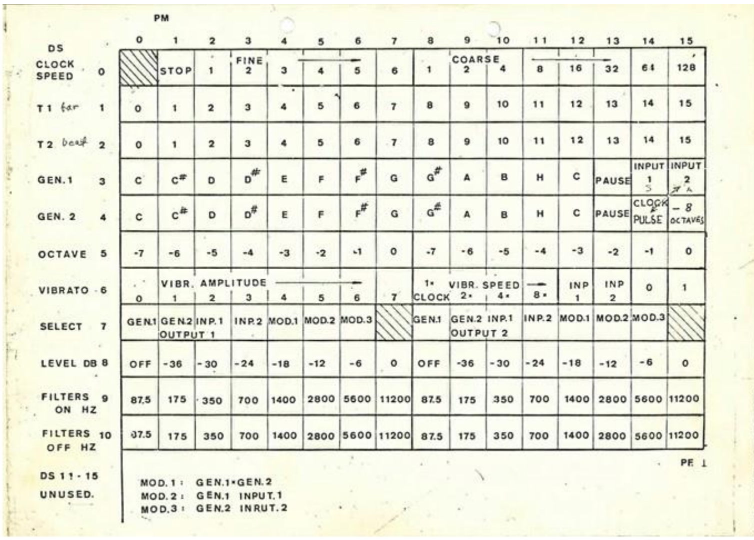


Figure 71. A detail of the user interface of the DICO: programming the ten bits of the instrument (photo: Mikko Ojanen and Jari Suominen 2004)

The *DIMI-A* is a two-voice synthesizer with a 256-step sequencer (see Figure 57, middle row, center). It is programmed by touching the metal plates with two styluses. The 2x16 plates are organized ergonomically in two quarter-of-a-circle groups – ostensibly 16 bars (left side) and 16 steps per bar (right side), when the instrument is used in the sequencer mode. The user activates the parameters from the left-hand side, and sets the values for the chosen parameter from the right. The parameters and their values are presented in the user manual (see Figure 72; upper image), which is typically in the form of a printed sheet of paper on top of the instrument. The user controls the running of the sequencer using the arrow-shaped plates on the upper-right corner of the user interface (see Figure 73; lower image), which can be started, stopped, reversed and manually stepped by touching the arrow plates. Changes in parameter value (i.e. commands) can be recorded on or erased from any of the 256 steps in the sequencer memory via controlling the R, E, D, 1 and 2 plates in the upper-left corner of the user interface. The memory can hold up to 100 commands, and several changes in the same parameter value can be programmed into one and the same memory location at a time, which is somewhat counterintuitive and causes the memory unit to behave in an unorthodox manner. (see Ojanen & Suominen 2005, passim.; Lassfolk et al. 2015, 266–270)

The programmable parameters include the clock speed (plate 0), jumping into any of the 256 steps of the sequence via the bar and beat selector (plates 1 and 2), the chromatic pitch of both of the two-tone generator (plates 3 and 4), an octave range over eight octaves (plate 5), the vibrato speed, depth and note bending upwards or downwards (plate 6), the signal-assignment (output and input channel or ring modulator) selector (plate 7), volume (plate 8), and setting the eight banks of band-pass filter either on or off (plates 9 and 10). As with the DICO, the DIMI-A can be used to process the external signal. The implementation of the signal-input technology in the DIMI-A resembles analog-to-digital conversion, and practically digitizes the inputted analog signal with a square wave and produces a strongly distorted digitized audio signal.

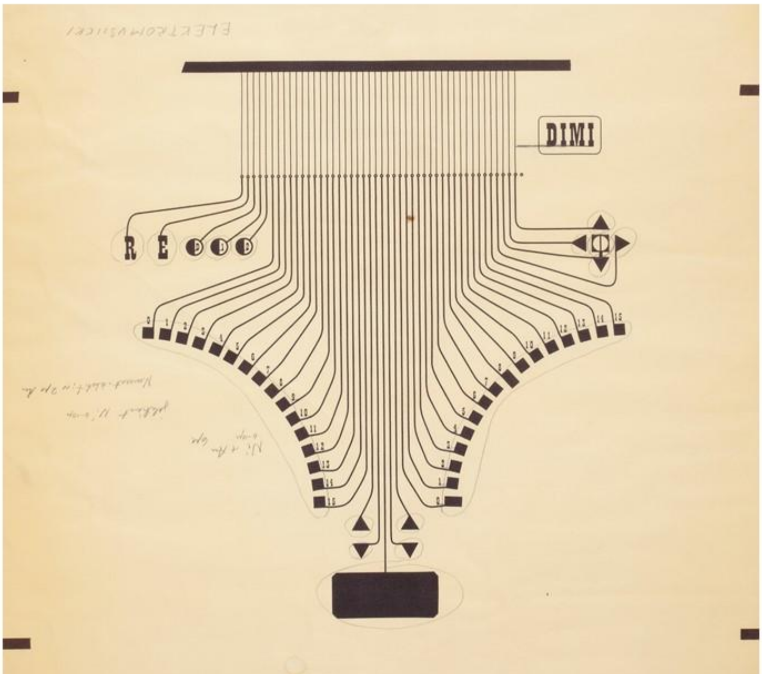


DS		PM 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLOCK SPEED	0		STOP	1	FINE 2	3	4	5	6	1	COARSE 2	4	8	16	32	64	128
T1 far	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T2 beat	2	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GEN.1	3	C	C#	D	D#	E	F	F#	G	G#	A	B	H	C	PAUSE	INPUT 1 S	INPUT 2 A
GEN. 2	4	C	C#	D	D#	E	F	F#	G	G#	A	B	H	C	PAUSE	CLOCK PULSE	– 8 OCTAVES
OCTAVE	5	-7	-6	-5	-4	-3	-2	-1	0	-7	-6	-5	-4	-3	-2	-1	0
VIBRATO	6	0	VIBR. AMPLITUDE 1	2	3	4	5	6	7	1• CLOCK	VIBR. SPEED 2•	4•	8•	INP 1	INP 2	0	1
SELECT	7	GEN.1	GEN.2 OUTPUT 1	INP.1	INP.2	MOD.1	MOD.2	MOD.3		GEN.1	GEN.2 OUTPUT 2	INP.1	INP.2	MOD.1	MOD.2	MOD.3	
LEVEL DB	8	OFF	-36	-30	-24	-18	-12	-6	0	OFF	-36	-30	-24	-18	-12	-6	0
FILTERS ON HZ	9	87.5	175	350	700	1400	2800	5600	11200	87.5	175	350	700	1400	2800	5600	11200
FILTERS OFF HZ	10	37.5	175	350	700	1400	2800	5600	11200	87.5	175	350	700	1400	2800	5600	11200

DS 11 - 15 UNUSED.

MOD. 1 : GEN.1•GEN.2
MOD. 2 : GEN.1 INPUT.1
MOD.3 : GEN.2 INRUT.2

PE 1

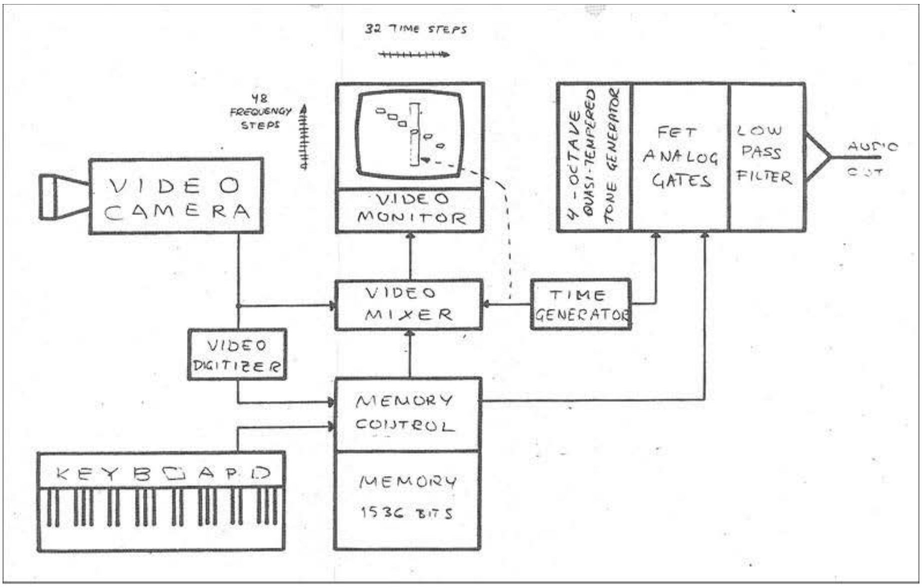


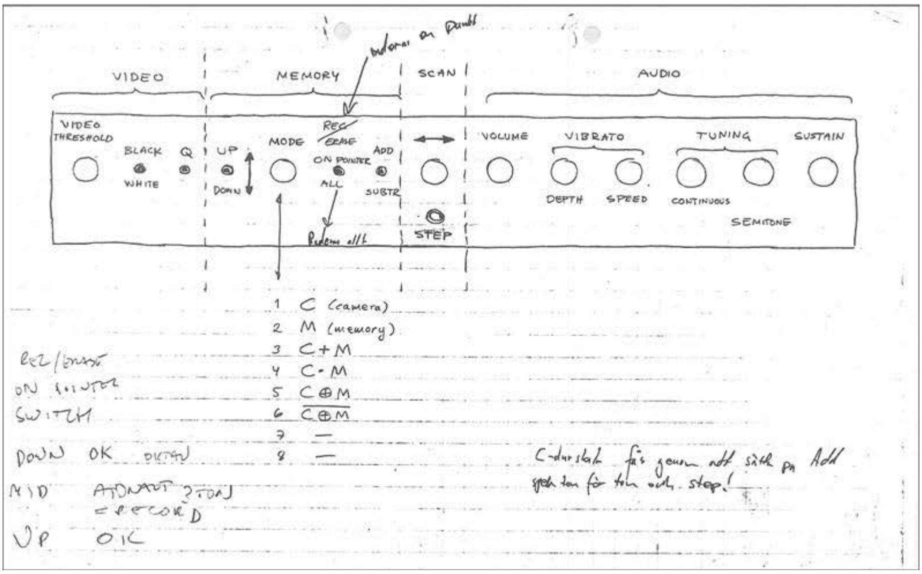
Figures 72 and 73. The user manual (upper image) and the user interface (lower image) of the DIMI-A Each row in the user manual equals the left-hand side quarter-of-a-circle plates touched with the stylus to choose the parameter, whereas each column in the user manual equals the right-hand side plates and alters the value of the chosen parameter when touched with the stylus. The lower print is the layout designed to be used in the etching of the user interface circuit board. The print-out is likely a version before manufacturing the first user interface and includes hand-written pencil markings (Ni+Au 6–10 µ; 6 µ; johtimet Ni 6–10 µ; Numerot + tekstit: ~2 µ Au) for different plate material properties such nickel gold and their width or thickness and ELEKTRO-MUSIIKKI – the name of Jouko Kottila's company where Kurenniemi likely built the first DIMI (see also Chapter 5.3.1). (print-outs: UHMRL archive)

Kurenniemi hoped that the *DIMI-O* (see Figure 58, middle row right), also known as the video organ, would overcome the problems detected in the DIMI-A user interface (see also Chapter 5.3.1). From the user's point of view, the instrument consists of five key elements (see Figure 74; upper image): the four-octave electric organ-style keyboard, the video camera, the video monitor, the 32-step sequencer (w/ full 48-note polyphony), and the control panel with the potentiometers, dials and switches to adjust the video camera, memory and audio functionalities (see Figure 75; lower image). Thus, the user could control the instrument with the conventional keyboard, via the video camera image and with the control panel. The sequencer can run in both directions at five different speeds, or the user can step up the pointer manually.

The instrument can be preprogrammed with frequency/note data, with different melodies or harmonies, for example. It has a 1,536-bit memory, with a 32-step sequencer and a four-octave chromatic keyboard (32x48). Depending on the memory input mode selected on the control panel, the notes can be recorded into the memory via the keyboard or video camera, or as a combination of their data according to different logical conditions. Thus, the instrument can read the static graphical notation in a studio environment, for example, or it can be used in a real-time live performance. The preprogrammed score in the memory can be manipulated, transposed either by semitones or continuously when the memory content runs upwards or downwards and causes an interesting sonic effect. The video-camera image is converted into black and white areas. Depending on the control-panel selection (e.g. luminance threshold and black or white dial), either light or dark areas of the image trigger the signal. When in the logical product mode of the memory and camera – in other words when "[a]ny particular tone is heard only if the corresponding note is present both in the memory and in the video signal" – the camera image can be used to trigger the notes recorded in the memory, and thus "pick the sounds from the air" (see the DIMI-O documentation).

Ideally, two users are required to operate the instrument, especially in live performances. In practical terms, one user either operates the camera or alters the content it sees, such as dancing in front of it, or shoots the surroundings or audience in the performance space, while the other user plays the keyboard and manipulates the video, audio and memory controls via the main control panel. Contemporary historical documentary material typically does not show the main operator – thus, his or her maneuvers are usually left unnoticed and any analysis of the performance is based only on the dancer's interaction with the instrument, resulting in a simplified description (see Niemelä 2019, 109–110).





Figures 74 and 75. The block diagram (upper image) and the control panel (lower image) of the DIMI-O (images: a copy of the DIMI-O documentation / UHMRL archive)

Kurenniemi continued to develop his instrument-control method and design in *DIMI-S* and *DIMI-T*. DIMI-S[357] is based on the electrical conductivity of the skin (see Figure 59; lower row, left). At least two people are required to play it, but it is optimally designed for a four-people group performance. Each player holds an iron ball in his or her hand and touches the other players on the skin. The earlier version had handcuffs instead of iron balls. The less clothing the players have on, the higher the number of connections. Thus, the DIMI acquired the letter S for Sexophone. (see Städje 2009; Suominen 2013, 151–154)

Ideally, the four players form six different pairs, which the instrument detects (see Figure 76). Each pair is assigned its own voice, the pitch of which is altered by the frequency-division setup each time the players in the corresponding pair touch each other. In effect, the instrument has six-voice polyphony and, depending on the connections between the pairs, all six voices can be heard at the same time. The voice of the pair is audible only when the players touch each other. The connections also alter the speed of the vibrato. (see Städje 2009; Suominen 2013, 151–154) Overall, the collective touching performance produces a seemingly randomized but consistent soundscape altered by the players touching each other. Thus, the alterations in sound, melody and harmony are beyond the players' immediate intentional control.

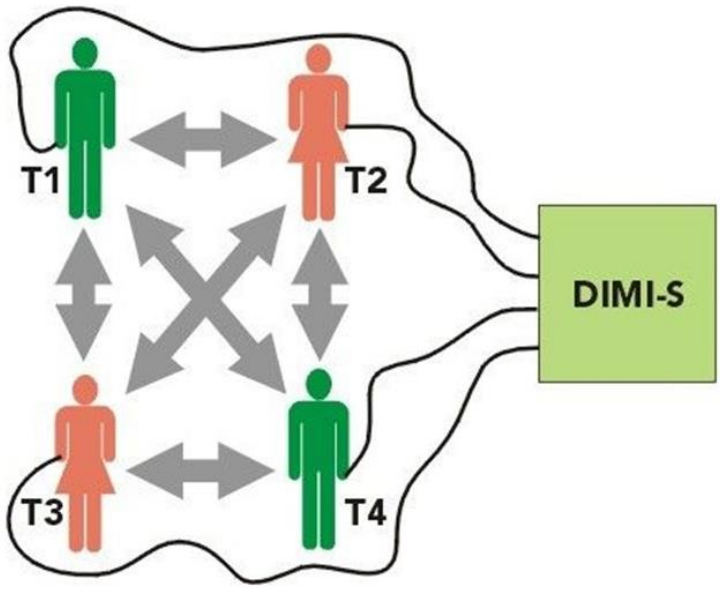
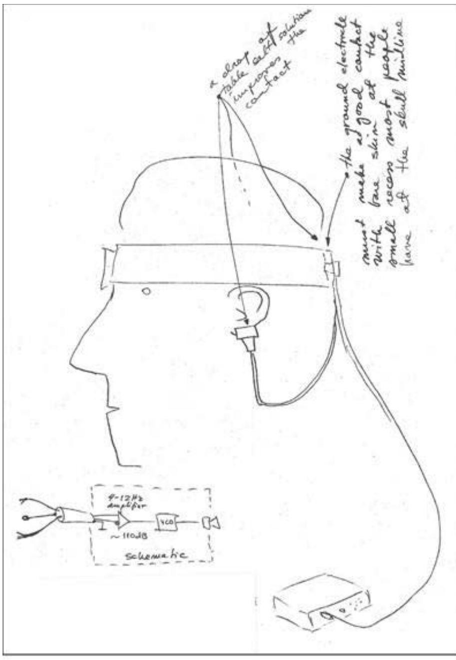


Figure 76. The six pairs formed by the four players of the DIMI-S (image: Städje 2009)

357 This description is based largely on the detailed analyses of the DIMI-S internal construction and working logic conducted by Städje (2009) and Suominen (2013, 151–154).

Kurenniemi went even further in his user interface testing with the DIMI-T (see Figure 60; lower row, center). The instrument is operated by electrical brain activity measured by EEG sensors from the player's scalp. The 500,000-times amplified EEG signal controls the pitch of the monophonic voltage-controlled oscillator. The player is recommended to fall asleep, or at least to reach a calm or drowsy state of mind to reach the alpha waves. Kurenniemi states in the user guide that, with a little practice, players could learn to manipulate the sonic output of the instrument – or even produce a recognizable melody (see Figures 77 and 78). This has neither been tested nor proved plausible, however.



DIMI-T Elektroenkefalofoni

Käyttöohje:

1. Paikallista aivojen keskiviivalla suunnilleen päälaen ja niskan puolivälissä sijaitseva pieni syvennys pääkallossa. Taivuta hiukset syrjään niin että päänahka paljastuu syvennyksen kohdalta. Hiero vähän suolaliuosta tai elektroditahnaa syvennykseen.

2. Aseta pääpantaan kiinnitetty elektrodi syvennykseen niin että metallinystyrä koskettaa mahdollisimman hyvin suoraan päänahkaan. Kiristä joustonauha pään ympäri ja liitä pannan päät yhteen otsan päältä joustonauhan päissä olevilla tarranauhoilla.

3. Kostuta johtojen päihin kiinnitetyt elektrodit suolaliuoksella tai elektroditahnalla ja kiinnitä ne puristimien avulla kumpaankin korvalehteen kuten korvarenkaat.

4. Kytke laite toimimaan kääntämällä valkoinen vipukytkin asentoon JOO. Ota mukava asento, rentouta kaikki pään lihakset, älä puhu, älä liikuta silmiä äläkä koskettele tai liikuta elektrodeja. Laitteesta tulevan äänen pitäisi nyt tasaantua epäsäännöllisesti huojuvaksi mutta mahdollisimman puhtaaksi säveleksi. Surina tai äänen ylenmääräinen poukkoilu johtuvat yleensä siitä että joku elektrodi ei tee hyvää kosketusta ihoon.

5. Ja sitten vain soittelemaan. Laitteesta tulevan äänen korkeus riippuu suoraan korvien välillä mitatusta aivosähköisestä jännitteestä (500000 kertaisesti vahvistettuna). Voit pian todeta että ympäristön ärsykkeet saavat aikaan vaikutuksia aivosähköisessä toiminnassa. Useimmat ihmiset pystyvät muutaman tunnin harjoittelulla havaittavasti vaikuttamaan omaan EEF:äänsä tahdonalaisestikin. Toistaiseksi ei silti ole tiedossa ketään joka hallitsisi aivonsa niin täydellisesti että pystyisi soittamaan edes kissanpolkkaa elektroenkefalofonilla.

6. Katkaise virta laitteesta käytön jälkeen (on paristoilla toimiva).

Dimi-T elektroenkefalofoni ei johda sähköä käyttäjänsä päähän vaan ainoastaan vastaanottaa ja on näin täysin vaaraton.

Dimi-T elektroenkefalofonia valmistaa:

Digelius Electronics Finland Oy
Luotsikatu 4
00160 Helsinki 16
puh. 90-669039

Figures 77 and 78. The DIMI-T user manual and playing instructions (images: the Finnish National Gallery collections, Erkki Kurenniemi archive; previously published in Kuljuntausta 2002, appendix; 2008, appendix)

Within the scope of this study, Kurenniemi's last electronic musical instrument was the *microcomputer-controlled analog synthesizer DIMI 6000* (see Figure 61; lower row right). The instrument's central unit consists of the processor, the sound generator, and the patch bay. The user programs the instrument with octal codes typed on the ADDS Consul 880 terminal. The digital control commands can be stored in two ITT SL 56 cassette mass storage devices, which were also used in real-time recording and in reproducing the digital control commands. Kurenniemi first wrote DISCORD software for the instrument, which allowed both the programming of sequences and real-time control via the ADDS keyboard. Later, Ruohomäki wrote DISMAL (DIS Music Assembly Language) and DISEQ sequencer software, which overcame the problems in Kurenniemi's original DISCORD software. The generator units consist of four oscillators with sine, triangle and square waveforms, ring modulators, two filters, and two audio outputs (see Figure 79). (see Lassfolk et al. 2014; passim)

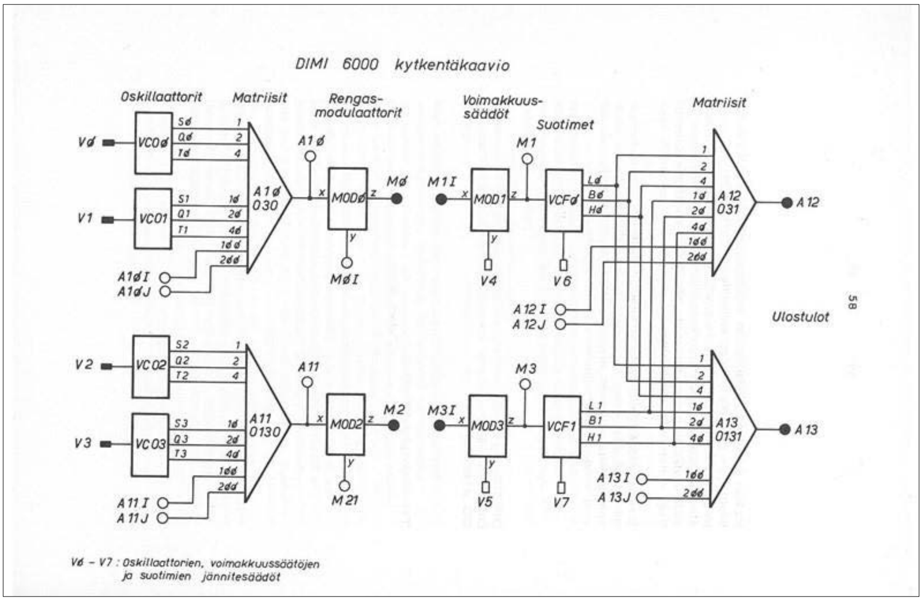
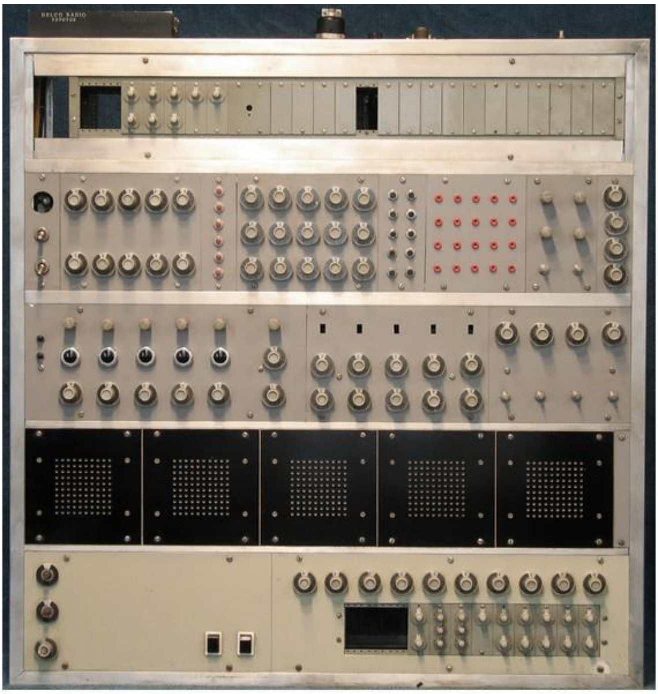


Figure 79. The DIMI 6000 block diagram (image in Sirén 1976, 58 / Digelius Electronics Finland)

6.2.2 The usability and functionalities of the user interfaces

The overall development of Kurenniemi's user interfaces, from the physical to the virtual, is clear if one compares his first and last designs – the Integrated Synthesizer and the DIMI 6000 (see Figures 80 and 81). All the parameters are visible (readable) and available to the user in the fully physical user interface of the Integrated Synthesizer, whereas the fully programmable DIMI 6000 hides all the parameters and control surfaces behind the machine code – with the exception of the typewriter keyboard, which could be programmed for real-time performance. Composers Pekka Sirén and Jukka Ruohomäki experimented with a few real-time performance options on the DIMI 6000, but even this feature required the instrument to be programed. (Lassfolk et al. 2014, [3])



Figures 80 and 81. The physical interface of the Integrated Synthesizer (1964) and the virtual interface of the DIMI 6000 (1975) (photos: Mikko Ojanen & Jari Suominen 2004)

Even though the user interface of the Integrated Synthesizer is physical, it is not tactile. In other words, the user does not experience the instrument as an extension of the body: it is more like an automated tool used to repeat pre-programmed patterns, with some real-time control over their development. The Electric Quartet (the mobile controllers), the Andromatic, the DICO, the DIMI-O, and especially the DIMI-S allow the user concrete tangible interaction with the instrument. Both the DIMI-A and the DIMI 6000, being fully programmable, as well as the DIMI-T have the most non-tactile user interface of Kurenniemi's instruments. It is worth noting here that the description applies to the historical situation, when the instruments were first used, and is based on contemporary historical documentary evidence. Later, in connection with recent research projects, new sonic potential has been discovered. However, comparison of the past and the present is beyond the scope of this study.

An interesting, albeit a-typical, prototype design feature of Kurenniemi`s user interfaces is that none of the controls, knobs, or potentiometers are labelled. This may be because most of the instruments were custom-designed and Kurenniemi knew who would be using them (see Ojanen et al. 2007, 92). However, this may not be a definitive explanation. In the case of the Andromatic, for example, Lundsten added hand-written labels to the key functions (see the description of the three potentiometers – pitch, gain and sustain – in Figure 82).

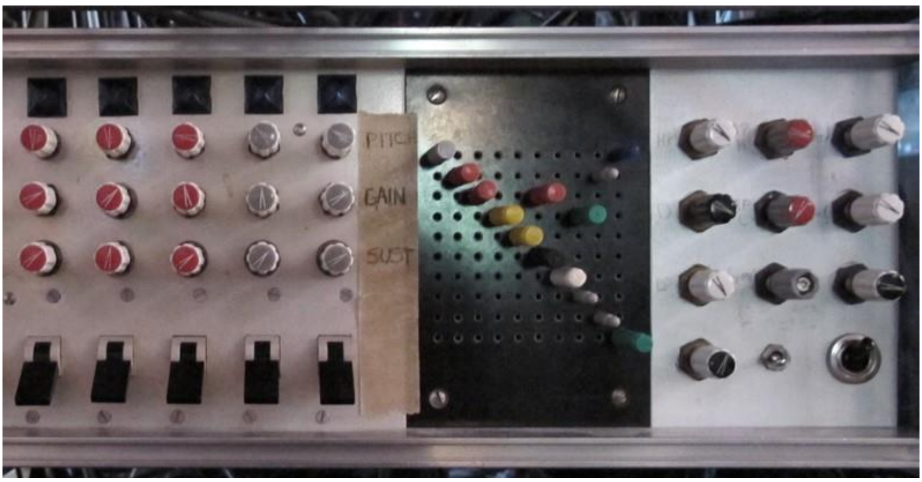


Figure 82. The Andromatic user interface (a detail), with hand-written labels for the pitch, gain and sustain potentiometers (Photo: Mikko Ojanen 2012)

In theory, the user can read the states of the Integrated Synthesizer, the Andromatic, the DICO, and the DIMI-O by looking at the potentiometers and switches – and the lights in the DICO user interface. This severely loads the user's cognitive processes, however, given that none of the functions are labelled and the user has to remember the meaning of each parameter and its values. In practice, the quantity of switches, potentiometers and dials in the Integrated Synthesizer makes it impossible to comprehend, or even to read. Readability and comprehensibility are enhanced in the simpler user interfaces used in the Andromatic and DICO, for instance, even if the content of only one sequencer step is displayed at a time in the latter.

Although the readability of most of Kurenniemi's user interfaces is high, the likelihood that the user will be able to comprehend the state of the instrument and to anticipate the potential sonic outcome is low. This severely constrains their usability in real-time setups or when a fast response from either the user or the technological artifact is required: in other words, it limits the machine-user interaction potential – in traditional performance settings. From an outside-the-box perspective, however, Kurenniemi's instruments set a potential point of departure for experimentation on musical interfaces. This is easily said in hindsight, of course, and it is the very feature that contemporary users could not surpass, and something that has been revealed only 50 years later in thorough research projects.

6.2.3 Control over the music-theoretical content and sound

The tuning and timbral flexibility of the instruments rely partly on their theoretical background. Magnusson (2009, 226) refers to the design of digital musical instruments as a top-down process, meaning that the designer must be aware of the theoretical basis of the implemented technological solution. Magnusson's notion of DMI design applies to most of Kurenniemi's instruments, even though many are hybrid in design, combining analog and digital electronics. In terms of note production, Kurenniemi relied mainly on the idea of frequency division. In the DICO this led to just intonation, meaning that the fourth and fifth intervals in the instrument's scale are pure. (see Suominen 2013; Lassfolk et al. 2015) What is notable here is that this was a by-product of the technical implementation rather than Kurenniemi's intention. The possibility to modify the desired intonation, that is the tuning or the scale, varies strongly from one instrument to another. The scale is fixed to chromatic tuning in the Electric Quartet, the DICO, the DIMI-A, the DIMI-O, and the DIMI-S, whereas users of the Integrated Synthesizer, the Andromatic, and the DIMI 6000 can modify the tuning more freely. The DICO user can modify the tuning to some extent by adjusting the tune of its four oscillators, even though the sonic output is always tied to the 12 discrete pitches.

Controllability related to the tuning is severely constrained in the DIMI-S and the DIMI-T, whose user(s) cannot intentionally play any melodies and the sonic output is determined by the instrument's internal structure: in the DIMI-S the manual step sequencer triggered by connections among the six different combinations of four players, and in the DIMI-T the randomized EEG signal measured from the user's brain, affected by the extensive noise in the signal due to poor electronic circuitry. The most flexible instrument in terms of tuning is the Andromatic in that the user is able to adjust the pitches on each of the ten steps of the sequencer separately and continuously.

6.2.4 The designer's initial ideas of the instruments' intended use

The intended use of Kurenniemi's instruments varies from one to another and depends on the point of departure of the design process. Here, the requests of the commissioners play the key role. The Integrated Synthesizer, the Andromatic, the DICO, the DIMI-A and the DIMI 6000 were primarily intended to be used in a studio environment – and primarily as general-purpose electroacoustic music studio devices, the first appearances of the Andromatic being an exception.

The Andromatic began to take shape in negotiations between Lundsten, Nilsson and Kurenniemi. In its first setups it was an integral part of sound installations in gallery and museum contexts, where it produced music and controlled the lighting of sculptures. In this sense, it could be considered a case-specific electronic music instrument for a sound installation. This is only partially true, however. Nilsson recalled how they pondered about the future instrument with Kurenniemi, specifically hoping for a general-purpose musical instrument that could be used to control certain musical parameters automatically.[358]

The Sähkökvartetti was initially designed to be used as a collective live-performance instrument, and later it served as a sound source in a studio setting. Meanwhile, the DIMI-S was designed to be and eventually was used exclusively in collective performances – some of them private events. The idea to make an instrument to be used only in collective performances came from Lundsten, who thought that it should be used only for fun, not in studio work (Ojanen et al. 2007, 92).[359] The DIMI-O was initially intended to be used either in the studio or in live situations.

6.2.5 The pre-programmability and playability of the instruments from the user's point of view

Even though the RCA synthesizer was Kurenniemi's key inspiration, significant differences are revealed when it is compared with his instruments. For example, the pre-programmability of his first systems in a specifically programmable or stored-program sense is not unambiguous (see Ulmann 2013, 2–3). The RCA synthesizer had a direct reference to a programmable computer when the composer could precisely determine the input parameters, whereas the parameter input of Kurenniemi's early instruments was approx-

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[358] Nilsson (2019) in an interview with Ojanen.

[359] See Ahlgren (1970, 7/*Svenska dagbladet* July 31, 1970); Widding (1970, 13/*Expressen* August 8, 1970); Brandel (1971, 7/*Aftonbladet* August 1, 1971); Pitkänen (1972, 7/*Iltasanomat* February 22, 1972).

imate. The Integrated Synthesizer, the Electric Quartet, and the Andromatic are sequencer-synthesizers rather than computers, in other words they are capable of producing musical sequences according to their internal states while being modified by their user. In this sense, Kurenniemi's first designs were closer to Buchla's Modular Electronic Music System, which was a musical instrument – a music easel as Buchla and composers Morton Subotnick and Ramon Sender called it – rather than a musical computer[360] (Bernstein 2008, 112–114).

Among Kurenniemi's instruments, precise programmability was first realized in the DICO, and the DIMI-A took the feature even further in that the design process was primarily directed by the computer metaphor. The four programmable parameters of the DICO (the note, the octave range, the articulation, and the output selection) can be stored with the 10 bits of its digital memory and can be programmed on each of the 12 discrete steps of the sequencer. The DIMI-A's memory, on the other hand, can hold 100 commands and its sequencer consists of 256 steps. The implementation of the memory structure of these sequencers is different: whereas DICO's memory equals the values of the 10 bits of discrete states on each step, DIMI-A's runs continuously and compares the state of the instrument with the 16-bit memory content. The programmability precision in these instruments is clearly on another level than in previous instruments with a memory equaling the physical states of their patches (either knobs or patching cords). However, even with the DICO and the DIMI-A, copying, pasting and modifying the memory content were either impossible or severely restricted, respectively. The fact that both instruments reset their memory units when switched off is detrimental to their use in slow-paced and long-term projects.

As the programmability feature became increasingly important the overall usability of Kurenniemi's instruments declined. This tendency reached its peak with the DIMI-A, the composer having to program all the musical gestures step by step: the instrument does not have an envelope generator and thus the dynamic alteration has to be programmed to the desired level of precision. This is exemplified in Kurenniemi's arrangement of Johann Sebastian Bach's Invention in A minor (see the analysis in Chapter 7). Kurenniemi outlined the key disadvantages of the DIMI-A before the instrument had been properly launched and the marketing started, and he started to envision improvements. First and foremost, to overcome the problem of unreadable memory content he added a video monitor and camera to read the graphical scores and to facilitate flexible instrument control. The video-camera experiment was followed by a touch-based user interface on the DIMI-S and an EEG-based user interface on the DIMI-T, whereas programmability ruled the instrument control in the DIMI 6000 – Kurenniemi's last DIMI of the 1970s (see Figure 83).

[360] See Buchla Associates (1966).

Figure 83. The DIMI 6000 was programmed with octal codes typed via the ADDS Consul 880 terminal. Typically, the cover of the terminal was removed to handle the heating problems.[361] Here, the instrument is seen in the University Studio (see also Figure 21). (photo: unknown / *Otavan iso musiikkitietosanakirja*.[362])

[361] Rautee & Hoikkala (2017) in an interview with Ojanen.

[362] See Ala-Könni et al. (1977, 147).

7 USER STORIES OF KURENNIEMI'S ELECTRONIC MUSICAL INSTRUMENTS

The focus in this chapter is on how composers and artists used Kurenniemi's instruments and the University Studio. I have ordered the presentation in line with their use 1) *within the studio environment* (Chapter 7.1) and 2) *outside the studio environment* (Chapter 7.2), in both cases broken down into sub-themes. Within the studio environment the key distinction is between *the studio as a tool for implementing compositional ideas* and *the studio as an instrument*, which were common themes in the 1960s and 1970s. Distinctive differences also arise when I consider how the computer metaphor that drove Kurenniemi's instrument design manifested in the use of his instruments. Switching the focus to *outside the studio environment*, I investigate how artists and composers used them in *live* and *collective performances*, and how Kurenniemi *demonstrated* his instruments. I also consider the distinction between live performance with an electronic instrument and the concert settings of electroacoustic tape music, which reveal interesting details from the perspective of users.

I categorize the composers and artists whose works and contributions I analyze in this study as 1) *users with first-hand experience* of the instruments, who had a key role in the design process and used several of them, or one instrument several times, and 2) *users whose experiences were more or less indirect*, in other words those who used only one instrument very briefly or whose contact was indirect, but whose experiences bring interesting insights (see Table 5). My analyses in this chapter concentrate on those with first-hand experience of the instruments. The source material provides points of departure for many research projects in the future.

It is noteworthy that Kurenniemi realized only a few works *with* his instruments: three with the Integrated Synthesizer (*Hyppy*, *Saharan uni*, machine poem improvisations), one each with the Andromatic (*Antropoidien tanssi*), the DICO (improvisation), the DIMI-A (*Inventio–Outventio*) and one *for* the DIMI-O (*Deal*). He produced only tests and demonstrations with the DIMI-S and the DIMI-T. There are no surviving documents about any of his works with the Sähkökvartetti or the DIMI 6000.

Table 5. The composers and artists with first-hand experience of Kurenniemi's instruments and those who were in in-direct contact with them: my analyses here concentrate mainly on the former group

Composer/Artist/Group	**First-hand / in-direct contact**
Ahvenlahti, Olli	In-direct exp.; together w/ Ruohomäki
Chydenius, Kaj	In-direct exp.; together w/ Kurenniemi and Donner
Bentley, Andrew	First-hand experience
Boman, Arild	First-hand experience
Davidow, Joe	First-hand experience
Donner, Henrik Otto	First-hand experience
Gothoni, Ralf	In-direct exp.; together w/ Ruohomäki
Hakala, Kari	First-hand experience; together w/ Kurenniemi
Harma, Heikki and Cumulus (the band)	In-direct exp.; together w/ Ruohomäki
Hauta-aho, Teppo	In-direct exp.; together w/ Ruohomäki
Keskinen, Kari	First-hand experience
Koivistoinen, Eero	First-hand experience
Kotilainen, Esa	First-hand experience
Kurenniemi, Erkki	First-hand experience
Lindeman, Osmo	First-hand experience
Lundsten, Ralph	First-hand experience
Mansnerus, Ilpo	In-direct exp.; together w/ Ruohomäki
Mattila, Raija	In-direct exp.; together w/ Kurenniemi and Donner
Nilsson, Leo	First-hand experience
Numminen, Mauri Antero	First-hand experience
Romanowski, Otto	First-hand experience
Ruohomäki, Jukka	First-hand experience
Ruutsalo, Eino	In-direct exp.; together w/ Kurenniemi and Donner
Salmenhaara, Erkki	First-hand experience
Sirén, Pekka	First-hand experience
Stan, Mircea	In-direct exp.; together w/ Ruohomäki
Sähkökvartetti (the band; Peter Widen, Arto "Mamba" Koskinen and Tommi Parko)	First-hand experience
Vainio, Riitta	In-direct exp.; together w/ Kurenniemi and Ruutsalo
Valkonen, Heikki	First-hand experience; on his own
Vesterinen, Marja	First-hand experience; together w/ Ruohomäki and Donner
Viljanen, Rauno	First-hand experience; on his own

The overall number of users with stories about Kurenniemi's instruments is small (see Table 6). Salmenhaara and Donner completed only a few electronic works, but the productions of Nilsson, Lindeman, Ruohomäki and Romanowski are more extensive. Swedish composer Ralph Lundsten is the exception, and I can describe only a fragment of his opus catalog in this context. Composers Pekka Sirén, Andrew Bentley, Kari Keskinen and Joe Davidow tested or employed Kurenniemi's instruments briefly – here I only introduce their contributions and focus on the composers and artists with more works. I present only the key points of the chosen examples of interest in this study. Detailed and updated lists of appearances and closer analyses will be available on the *Electronic Musical Instruments by Erkki Kurenniemi* website and within the FinEARS project.

Table 6. Kurenniemi's electronic musical instruments: an overview of the users and use situations (based on Table 3 in Chapter 5)

Instrument	Used during	Within the studio	Outside the studio	Known users of the instrument (the primary user first)
Integrated Synthesizer	1964–68	in several works	only twice according to known documentary evidence	Kurenniemi, Lundsten, Nilsson
Sähkökvartetti	1968– the mid '70s	in only a few works	in several performances	Numminen with Sähkökvartetti (the band), Ruohomäki, Vesterinen
Andromatic	1968–	in several works	used once in Finland; in several exhibitions outside Finland	Lundsten, Nilsson, Kurenniemi (once)
DICO	1969–74(?)	in several works	used twice; in a Yle seminar and in Elektrononstop	Lindeman, Kurenniemi (once)
DIMI-A	1970–78(?)	in several works	Demonstrated a few times; only one live performance	Ruohomäki, Lundsten, Valkonen (twice), Viljanen (once?), Kurenniemi (once), Salmenhaara (once)
DIMI-O	1971–	in several works	several performances	Lundsten, Ruohomäki, Vesterinen, Kurenniemi, Koivistoinen
DIMI-S	1972–	-	several performances	Lundsten; Visitors at the Pripps brewery
DIMI-T	1973–	-	one test; one demonstration	Kurenniemi (once); Boman
DIMI 6000	1975–	only in a few works	-	Ruohomäki, Sirén, Davidow, Bentley, Keskinen

In the following I build on information from the composers and artists about how they view their artistic work, gleaned mainly from contemporary documents, retrospective interviews, and music analysis. I address the question of what these works reveal about the technology used in their realization. My point of departure is the material description of the works and the composers' poietic ecosystems guided by the relevant features (*the pertinences*) I have detected and consider significant for the analysis (see Chapter 3.3).

7.1 Within the studio environment

I described the historical development of the University Studio in Chapter 5, and tracked *who* used it. Here, I return to *how* the composers used the studio and Kurenniemi's instruments within the studio environment.

7.1.1 The composers' attitudes towards studio work and technology

Many of the composers and artists presented here saw the studio as an essential tool *for implementing their compositional ideas*, whereas only a few valued it *as an instrument*. The distinction between these working methods is based on two types of workflow: composers and artists viewed it either 1) as a tool with which to realize their prescribed plans or mental schema, or 2) as a real-time instrument, and interacted with the technology without a prescribed plan.

Users of the University Studio to whom Kurenniemi's utopian vision of an automated, distributed and computerized infrastructure was out of reach based their works mainly on tape manipulation and sound processing. Despite the shortcomings of the contemporary technology, the studio provided invaluable facilities enabling composers and artists to experiment and compose with – and in some cases even for – the new instrument. In the processes of composition and music production they prioritized composer-centeredness over technology-driven workflow. However, users differed in how they used the studio, and here their backgrounds played a significant role. A comparison of users who were formally trained in composition with autodidact composers or trained engineers, for example, reveals differing attitudes towards studio work.[363] This emerges clearly when one looks at the respective workflows.

Typically, the composers first improvised with the instruments to test the features and to discover their sonic and musical potential. Occasionally, the technology provided a point of departure for a compositional solution, but only rarely did technology per se constitute a complete compositional setting. Within the studio context, Kurenniemi's individual instruments were mainly used as sound sources. The composers outlined their initial ideas for their compositions before realizing them, and the technology merely directed the implementation. Here, the composers differed in their real-time interaction with the instruments and in the role they were willing to give to technology.

Kurenniemi in particular made use of the studio as an instrument for real-time processing. His key standalone tape music works – including *On-Off* (1963) and *Antropoidien tanssi* (1968) – are based on real-time interaction with the studio technology. In addition, the soundtrack for Eino Ruutsalo's experimental film *Hyppy* (1965), the two-piece tape music work *Saharan uni I & II* (1967, realized with Kari Hakala), and some of Ruutsalo's tape collages including *Mix Master Universe* (1973, realized with Jukka Ruohomäki), and *?Death* (1972–75) were produced as spontaneous processes without a prescribed plan, even though the collages required laborious editing and splicing.

Whereas Kurenniemi saw the studio as an instrument for real-time performance, Salmenhaara and Donner composed according to a plan outlined beforehand, even though they did not necessarily commit the score to paper. Kurenniemi thus used the studio as a preprogramed instrument whereby he could improvise, while Salmenhaara and Donner used it mainly as a sound-manipulation facility. Both Donner and Salmenhaara experimented with studio technology and produced works with it during the 1960s, but both abandoned electronic means before the turn of the decade.

Donner, who was one of the first users of the University Studio, described it as a place in which he could work on experimental and unconventional

[363] It should be noted that there was no formal training for studio-based composition at the time. I am grateful to Dr. Andrew Bentley for this information.

projects.[364] At the time, he was also utilizing Yle premises. Yle did not have a studio dedicated to experimentation and the work had to be done at Tehosto or in the radio theater, and according to a formal plan, which hindered the experimentation. The University Studio provided a freer and more open environment for working without having an official project. In addition to using studio facilities in Helsinki, Donner worked in several studios in Central Europe, and was thus aware of stylistic trends and of the technological potential of the new medium. For him, a studio was a tool just like any other instrument. The key studio works he created by electronic means include the soundtracks for Eino Ruutsalo's films *Kaksi kanaa* (1963) and *Romutaiteilija* (1965), a standalone tape music work, *Esther* (1963) and the radio play *Vihreä eläin* (1971).

Salmenhaara emphasized the role of the composer in music production. He pointed out that technology did not dictate compositional decisions, and that the studio played the same role in the compositional process as musical instruments did in more traditional music. He thus shared Donner's view of the studio as a tool with which to realize compositional ideas.[365] Salmenhaara's electronic repertoire from within the studio environment includes the standalone tape music work *White Label* (1963), the two-part tape collage *Information explosion* (1967), and two soundtracks for TV documentaries, *Aggressio* (1968; Engl. Aggression) and *Maan aurinko* (1968/70). (Ruohomäki 2020, EH24/1; Uimonen 2007, 89–90) Having completed *Maan aurinko* Salmenhaara abandoned electronic means altogether. Donner and Salmenhaara thought of the studio mainly as a potential tool for implementing their musical ideas according to prescribed plans or mental schema.

A few details in Lundsten's and Nilsson's works reveal their points of departure for electroacoustic music composition and production. Kurenniemi's instruments played a significant role for both, but it seems from the way they used them that they employed the sounds to suit their needs rather than utilizing the features of the instruments to drive their compositional decisions. Occasionally Kurenniemi's instruments have a solo role, and they clearly stand out from the accompanying background. Even when the sounds are modified by means of tape splicing, overdubbing and reverberating, or blended in with other sounds, their sonic characteristics and certain sequencer functionalities are recognizable.

Nilsson describes how he outlined sketches for works but did not write strict plans or scores.[366] Once he had completed the work on tape the sketches became obsolete and he threw them away. Here, the contrast to Kuren-

[364] Donner (2013) in an interview with Home & Ojanen.
[365] Salmenhaara (1968, 208); see also Tawaststjerna's funding application dated January 26, 1967: "Mainittakoon, että studiossa realisoidaan parhaillaan Montrealin maailmannäyttelyyn tilattua elektronista sävellystä. / Helsingissä 26.1.1967 (Erik Tawaststjerna)." (Engl. "It should be noted that an electronic composition commissioned for the Montreal World Expo is currently being realized in the studio. / Helsinki, January 26, 1967 (Erik Tawaststjerna)")
[366] Nilsson (2019) in an interview with Ojanen.

niemi's spontaneously recorded work *Antropoidien tanssi* with the Andromatic is clear. Nilsson employed tape loops and overdubbing in *Skorpionen* (1964), in other words he compiled the previously recorded sounds of the Integrated synthesizer with tape recorders afterwards – even though he said that the "instrument sounds were relatively unedited".[367] Unlike Nilsson, Kurenniemi did not employ any post-processing or overdubbing when he composed *Antropoidien tanssi*, but simply compiled the work from three tape segments by means of sharp splicing.

In the end, of the instruments in Kurenniemi's collection Lundsten used the Andromatic and the DIMI-O in several works. He did write a few scores for the DIMI-A and even demonstrated the instrument frequently on TV documentaries,[368] but he soon cast it aside and donated it to Musikmuseet in 1978 (see Chapter 7.1.5). According to the interview with Städje (2012), Lundsten tried to break free from the 12-tone scale system, which was one of the key restrictions of the DIMI-A. However, this comment should be further considered. The DIMI-O, which was one of Lundsten's favorite instruments alongside the Andromatic, was as tightly intertwined with the 12-tone scale as the DIMI-A was. The key differences between them lie in the interfaces and their usability.

Composer Osmo Lindeman described how he drafted notes when he started to compose a work,[369] however, the notes were rudimentary and none of them have survived. In this sense, his workflow resembles Nilsson's. Lindeman systematically tested and experimented with the equipment. His systematic way of working in his studio is exemplified in a surviving tape in which he tests the balance of the original dry test signal and reverbed signal by reading the values of the volume input parameter potentiometer on the tape step by step to verify the suitable amount of reverb effect.[370] This working method is also evident in the textbooks on electroacoustic music technology and composition he compiled for students at the Sibelius Academy. Furthermore, his uncompromising attitude drove him to study electronics and computer technology from scratch. He thereby acquired a thorough understanding of and expertise in electronic music composition, having abandoned composing for traditional orchestras – even though he was a trained composer.

Lindeman was cognizant of the technology in most of Kurenniemi's instruments, and even included technical descriptions in his textbooks. However, in his own works he only used the custom-built DICO – and indeed, he was the only user of the instrument. Lindeman's early electronic works be-

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[367] Ibid.

[368] See Sima, Jonas. (1973). *Cosmic Love. Ralph Lundsten elektrontonsättare*; Ett porträtt av Jonas Sima. http://www.svenskfilmdatabas.se/sv/item/?type=film&itemid=56455; http://www.sima.nu/film-cosmic.htm

[369] See Lindeman (1972) in an interview with Koskimies or Lindeman (1974) in an interview with Paalanen.

[370] See UHMRL digital tape archive, tape ID: 20180711_01.

fore *Ritual* (1972), composed in 1969–1971, are based almost entirely on DICO sounds and sequences, having been composed with and in some sense even for the instrument. His standalone tape music works largely consist of similar and sometimes even the same sound material produced with the DICO. Examples include *Kinetic Forms* (1969), *Mechanical Music for Stereophonic Tape* (1969), *Tropicana* (1970), and *Midas* (1970), as well as his music for exhibitions *Mobile* (1969), the experimental film *Tämäkö on teddykarhun maailma?* (1969), and the two-part dance fantasy for television *Hummerit ja hummarit. Hummarit ja hammarit* (1972).

The unifying feature of these works is the relationship between their overall structural organization and their constituent parts. The early electronic works consist of various DICO-realized segments and sound gestures, which are then compiled with tape recorders to form the final version. Because the sketches have not survived, no closer analysis of his composition workflow is possible. The reuse of sequences and sound gestures recorded with the DICO implies that Lindeman's composition process was, in turn, driven by real-time interaction with the technology and his plans for structural organization. Here, he both performed with the DICO in real time to produce the segments and sound gestures, and he composed according to a prescribed plan to form the overall structure of his works.

After *Midas* (1970) Lindeman concentrated on studying electronics and computer technology, which changed the style of his electronic works. The DICO has a significantly smaller role in *Ritual* (1972) than in his previous works. He abandoned it in *Spectacle* (1974) and realized the sounds with the Putney and the Minimoog. He also blended the individual sounds of the instruments more tightly with other sounds in these later works, and even processed them beyond recognition. The difference from the early works is clear –both in his technique and in the perceivable sonic character of his composition. He went on to abandon his early electronic works, of which he considered *Ritual* and *Spectacle* the only official examples.[371] He pointed out that the first works were mere studies, which he had "accepted too easily": he was concentrating on his instrument, not on the composition process.

Lindeman's expectations and anticipation of the new medium, electronic music, were not fulfilled. Eventually, he faced the same problems as when he composed traditional orchestral music.[372] His comments reveal a similar attitude to that of Salmenhaara: technology does not dictate compositional decisions – nor is it equipped to do so. The way Lindeman used the DICO sequencer in real time also reveals more about his attitude: as he states in a description of his last orchestral work *Variabile*[373] (1967), he aimed at total composer control over his works. This extended to all aspects of his work,

[371] Lindeman (1975) in an interview with Sermilä.
[372] Lindeman (1975) in an interview with Sermilä.
[373] See the *Variabile* presentation text in Lindeman's scrapbook: "Even though the work includes aleatoric features, there is nothing in it that is beyond the composer's control".

including its performance, and it was one of the main reasons why Lindeman abandoned orchestral music. His early electronic works were strongly driven by the DICO, which eventually compromised his ideal of total control over the composition process.

The first works of composer of electroacoustic music, researcher, and teacher Jukka Ruohomäki exemplify his way of working in close interaction with studio technology. He states more explicitly than others that his composition process is centered on listening to the sound material. Ruohomäki started his studio work with the DIMI-A in particular, and first used it to produce *Kolme DIMI-aihetta* (1970, Engl. Three DIMI themes) and his first standalone tape music work *Mikä aika on* (1970, Engl. What time is). Early on, he also arranged Johann Sebastian Bach's Invention in C major for the DIMI-A.

Kolme DIMI-aihetta consists of drone like passages recorded on tape and then overdubbed with each other. The synchronizing of pre-recorded tapes with recorders played a key role in *Mikä aika on*. Ruohomäki came to rely on the overdubbing and manipulation of sounds with tape recorders to produce a layered soundscape as a composition technique in the studio context. The soundscapes in *Sähkölintupuutarha* (1971/1974), *Adjö* (1974), and *Pisces* (1975–76), which also exemplify his distinctive imitation of nature, are exceptionally rich due to the multilayered overdubbing. Ruohomäki also developed a delicate technique for using synthetic sounds to imitate nature. Having started with a purely synthetic and tonal sound world, he developed his compositional and sound-material-selection techniques during his first compositional period in the 1970s to incorporate concrete sound sources and skilled tape manipulation. (see Ojanen 2014b)

Composer, artist and teacher of electroacoustic music Otto Romanowski makes a rigid distinction between improvisation and studio work. He allows improvisation only in live situations and when acquainting himself with new technology but declines it as a part of a tape composition. His point of view reflects Landy's (1994) "something to hold on to factor", calling for components in a musical work that maintain the listener's interest throughout. Romanowski realized various works in the University Studio, and to some extent with Kurenniemi's instruments, including *Study 21 a* (1973), *Study 21 b* (1974), *Yesterday-Tomorrow* (1974), *REM* (1974), *Two Dreams* (1975), *Two Visions* (1975), and *Through the Black Point* (1976).[374]

Romanowski uses strongly contrasting sounds. As concrete raw material in his early works he typically used human sounds, and their contrast to electronic sounds is clear. In *Yesterday-Tomorrow* (1974), for example, the aggressive electronic rhythmic pattern is followed by a similar pattern produced by a chanting choir. The instruments are typically processed beyond recognition, which indicate that in his early electronic works he moved fur-

[374] Romanowski (2019) in an interview with Ojanen.

ther away from his initial technological point of departure than Kurenniemi, Nilsson, Lundsten and Lindeman, for example. Romanowski built an individual system, such as a language or a grammar, for each of his stand-alone tape music works. However, he wanted to add surprising elements even in works that otherwise had predetermined static structures, which nevertheless were also based on prescribed ideas. For example, he inserted a multiply speeded-up copy of *Through the Black Point* (1976) in the golden section of the work, where it is heard as a snap. This speeded-up version also provides a new time dimension for the work[375] in that the listener has actually heard it before it ends. Another time dimension resembles the relative elapse of time in the black hole, which is the title of the work in question.[376]

In the following subsections I take a closer look at the chosen works.

7.1.2 The studio as a real-time performance instrument

Closer analysis of the standalone tape music works reveals composers' different points of departure in their studio workflow. Analysis of the music also reveals details about the technology used in the studio. For instance, Kurenniemi's first tape music work *On-Off* (1963) clearly differs from works such as Salmenhaara's *White Label* (1963) and Donner's *Kaksi kanaa* and *Esther*, both completed in 1963 – and even from its foreign counterparts such as Nilsson's *Skorpionen* (1964), *Omaggio a Emilio Vedova*[377] (1960, RAI studio in Milan) by Italian composer Luigi Nono, and *Analog #1: Noise Study*[378] (1961, Bell Labs) by American composer of computer music James Tenney. Even though the chosen works are similar in many respects, their comparison reveals Kurenniemi's unique approach.

Kurenniemi realized *On-Off* as a live improvisation: the studio equipment recorded it directly onto the master tape, which he did not edit afterwards.[379] Other composers presented here processed the material for the master tape manually, Tenney being among them, even though his work is an early example of music composition by computer (Tenney at al. 2015, 103). Kurenniemi's working method deviated from the typical process of electroacoustic music composition, which was based on careful tape splicing. The outcome is that *On-Off* has no structure determined by its composer beforehand, and in this respect it exemplifies technology-driven composition, meaning that the composer works in close and real-time interaction with the studio equipment.

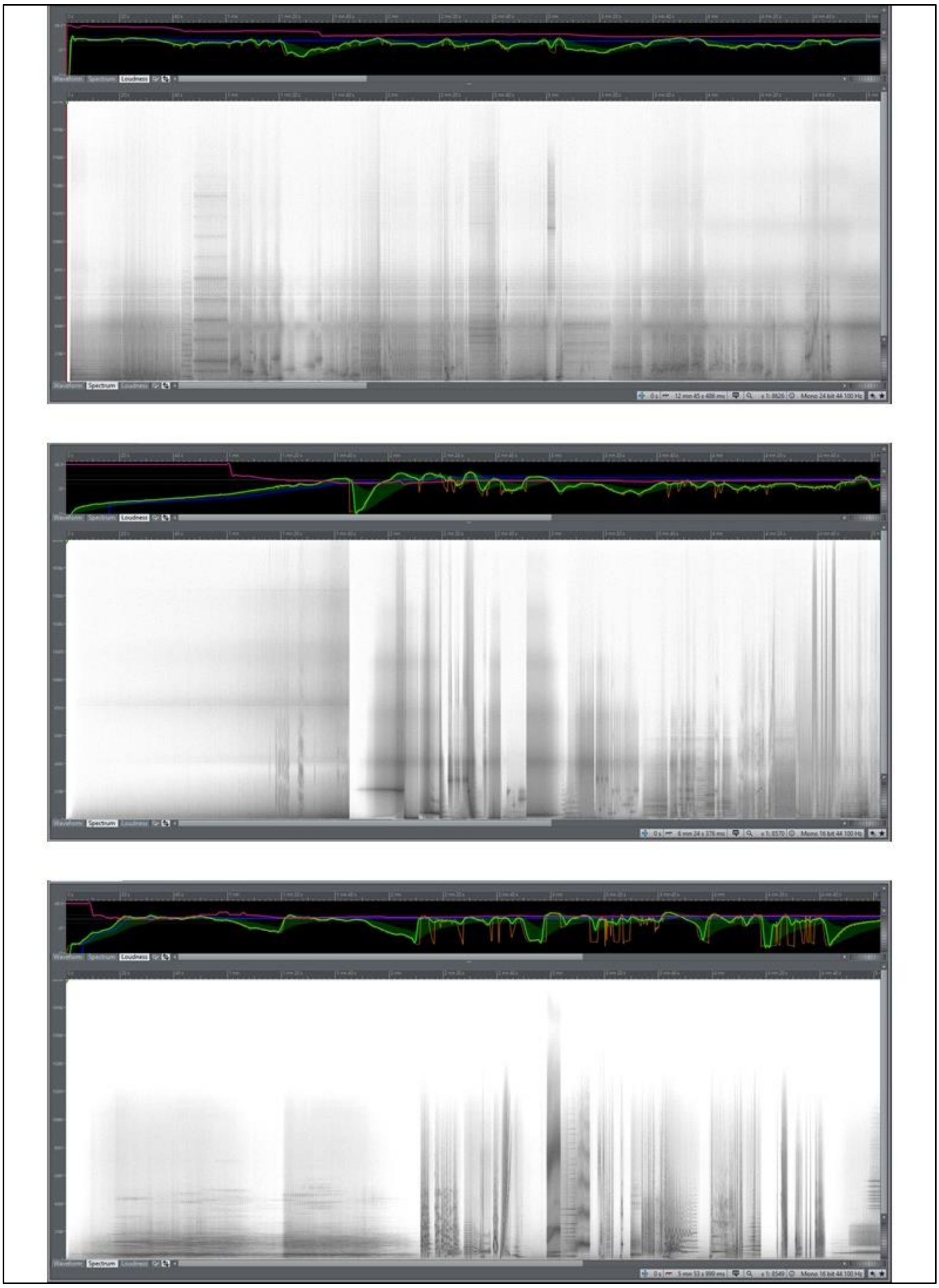
[375] The duration of the work is 8 m 40 s (8:40 = 520 s), therefore the golden section is at 5 m 21 s (520 s*0,618=321).
[376] Romanowski (2019) in an interview with Ojanen.
[377] See: https://youtu.be/8WAjjtNVVKg
[378] See: https://youtu.be/fe4UlyQAgcc
[379] Salmenhaara (1964, 55).

The original sound material for Kurenniemi's, Salmenhaara's and Donner's first works may have been concrete, or even based on discrete pitches. The sound processing distorted the material beyond all recognition, however, with rich spectral features closer to noise than the tonal or pitch-oriented structures. Thus, noise is a significant component of these works. In this respect, it is interesting that Kurenniemi's instruments – apart from the Integrated Synthesizer – did not include noise generators, the emphasis in his design being on the sequencers, which produced distinctive pitches with pure, tempered or flexible scales. Donner realized *Esther* in Bilthoven – not in the University Studio – although here his work serves as a reference point for those from the studio. All three works were premiered in the same concert in the Jyväskylän Kesä festival on July 13, 1963. Saunio describes Salmenhaara's and Donner's works as studies and drafts in his review, but he refers to Kurenniemi's *On-Off* as a work with a distinctive mark of the composer's determined intention, and Kurenniemi as a "composer who knows how to achieve his goals".[380]

According to Kurenniemi, his point of departure for *On-Off* was a "static hum" without any strict structural form.[381] Retrospectively, he said he was inspired by a static hum in the generator hall of a power plant, which he had visited a few years earlier. Interestingly, Tenney referred to a similar acoustic phenomenon – driving daily through the Holland tunnel in New York – as an inspiration for his noise study (see Tenney et al. 2015, 98–99). It is noteworthy that Kurenniemi wrote a description of the work fifteen years after it was completed. The point of departure manifests itself in the work, however, and is clearly visible in the sonogram (see Figure 84; the upper image). Unlike Tenney, with his careful documentation (see Tenney et al. 2015, 100–103), Kurenniemi did not write a score for the work, nor did he document the studio setup he employed. Thus, it is impossible to conduct a comprehensive analysis of the poietic ecosystem in which he produced it.

380 Saunio (1963, 4/*Ylioppilaslehti* August 30, 1963). It is noteworthy that Saunio was a close colleague and friend of Kurenniemi, Salmenhaara and Donner.

381 As Kurenniemi states in the program of a seminar in 1978, "[t]he point of departure for the work was a static hum, the duration of which would not have any meaning structure-wise": as in the program text in the archive of Yle's experimental studio (Kuljuntausta 2002, 389; see also Kuljuntausta's translation in 2008, 205). The document has vanished from Yle, however, apparently during the dismantling of the studio. The quotations from Kuljuntausta's books are the only surviving references to this document.



Figures 84–86. Sonograms of *On-Off* (1963) by Kurenniemi (upper image), *White label* (1963) by Salmenhaara (middle image), and *Esther* (1963) by Donner (lower image) depicting the first five minutes of each work to allow for structural comparison across them. The horizontal bars, both dark and light, in the upper image indicate the static frequency clusters running throughout Kurenniemi's *On-Off*, whereas *White label* and *Esther* consist of structural segments, and even pauses in between them. (image: Ojanen)

The distinctive feature of *On-Off* is its static timbre, which manifests throughout the work as dark and white horizontal stripes in the sonogram. The darkness of the stripe varies as the amplitude of the sound[382] changes (darker is louder). The emphasized frequency bands are responsible for the static nature of the work, although the dynamic variation in loudness is considerable – ranging from approximately RMS -65 dBFS to -5 dBFS.[383] According to Lassfolk (2012, 60), continuous noise textures serve as an intensive pedal point on top of which different sound gestures are laid. These gestures appear in the sonogram as dark vertical figures.

Whether Kurenniemi used a tape loop to create this continuous static hum or played a 15-minute prerecorded tape of materials is impossible to confirm. There seems to be no periodic sequence, or the loop was long and its edit vanished under overlaying sound gestures. In comparison with the works of Salmenhaara and Donner the differences are clear: *White label* and *Esther* are realized from segments, which form the structure of the work, whereas *On-Off* is dominated by static noise clusters throughout its duration. Kurenniemi recalled in 2004 that Luigi Nono, who was at the premier of the work during the Jyväskylän Kesä festival, asked if he had heard about pauses, and remarked that they, too, are useful musical material.[384]

Some of the sound gestures and certain passages in *On-Off* provide insights into the technology and techniques used in the realization of the work. At the time, "the equipment of the studio was modest" and included a couple of full-track tape recorders, sound generators and a spring reverb unit[385] (Kuljuntausta 2002, 389; 2008, 205). The inventory catalogue reveals that at least the Heathkit oscillator and the Telefunken M24 tape recorders were at Kurenniemi's disposal. According to Kurenniemi, all the material used to produce the work was recorded beforehand and no tone generators were used during the production of the master tape (ibid.). Kurenniemi used prerecorded, pure electronic sounds produced with an oscillator and noise generator, although the origin of these sounds remains unknown due to the extensive signal processing. Kurenniemi recalled that he was not aiming at the French *musique concrète* style.[386]

Some of the sound-processing equipment – i.e. the spring reverb, the ring modulator and the feedback line through a mixer of some sort – is detectable in the work. Even though the origin of the sound material remains unidentified, there is one interesting sound gesture that was impossible to produce in the University Studio given the setup and its equipment at the time: the fast arpeggio (see Figure 87) appears twice, the first time for about two minutes,

[382] That is perceived loudness; shown in the graphic presentation along the sonogram.
[383] The dynamic range is assessed from the original master tape of the work digitized in 2012. On the attachment CD of his book On/off, Kuljuntausta released a compressed version of the work, where the dynamic range is significantly reduced. (see also Ojanen 2015)
[384] Kurenniemi (2004) in an interview with Ojanen and Suominen.
[385] Salmenhaara (1964, 55).
[386] Kurenniemi (1993a) an interview with Ruohomäki.

clearly audible although heavily reverbed. The arpeggios resemble the sonic characters of Seppo Mustonen's early experiments with computer music *Teema ja muunnelmia* (Engl. Theme and variations; 1962), which he produced with the Elliott 803 B computer of Suomen Kaapelitehdas. Kurenniemi recorded these experiments and processed the tape with a spring reverb. *Teema ja muunnelmia* was performed at the Jyväskylän Kesä concert, together with *On-Off*.

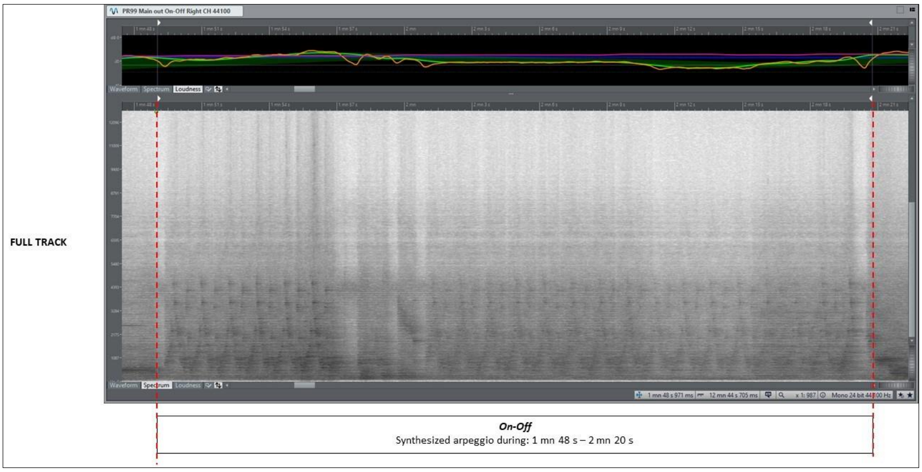


Figure 87. *On-Off* – a detail: arpeggio with electronic sounds, 1:48–2:20; a similar pattern appears again during 7:32–8:00 (image: Ojanen)

The passages in which no sound gestures appear are interesting, and emphasize the casual nature of the work, such as in the static passage of 4:46–5:55 (see Figure 88). Here, the hectic action of sound gestures disappears, and the background noise texture is left alone for over a minute.

There is more to be said about the length of the work and about Kurenniemi's real-time working method. Kurenniemi realized the final master tape of the work during its approximately 13-minute duration. However, this required him to prepare the tapes and to connect and test the equipment in advance, among other required procedures. It is impossible to know if his intention to complete this work became firm at the moment he improvised with the studio, long beforehand,[387] or after the improvisation was over. The container of the master tape does not include exact dates or other markings.[388]

[387] As Kurenniemi acknowledged, the inspiration for the piece was a hum in the generator hall of the power plant that he had experienced a couple of years earlier (Ruohomäki 2020, EH22/5); Kurenniemi also recalls in Taanila (2002) that the acoustic experience occurred in his childhood.
[388] See Ojanen, Mikko. (2020). *The Photo Set of the Master Tape of Erkki Kurenniemi's On-Off* (1963) (Version 20200108_01). Zenodo. http://doi.org/10.5281/zenodo.3601403.

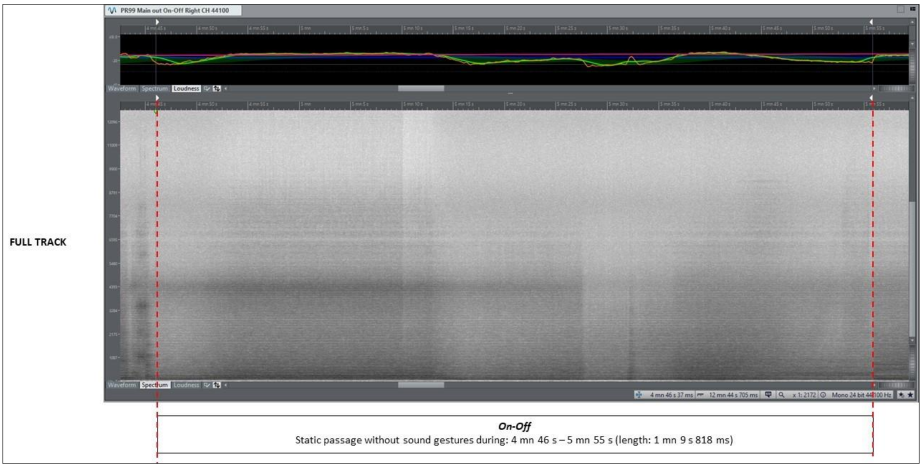


Figure 88. *On-Off* – a detail: static passage, 4:46–5:55 (image: Ojanen)

The work's structure does not fully support the initial idea implied in its name, in other words that music can be produced with a machine by turning the power on and off. Kurenniemi recalled that the meteorologists in the next room did not appreciate the sonic textures of *On-Off* as music, and that the session may even have been halted due to their complaints.[389] The long and calm fade-out in particular emphasizes the delicate structural details rather than the crudely interrupted ending when the music-producing machine was turned off, or when the composition process was surprisingly halted by the neighboring meteorologists (see Figure 89).

[389] See Kurenniemi (2004), interview with Ojanen and Suominen; see also Ruohomäki (2020, EH22/5).

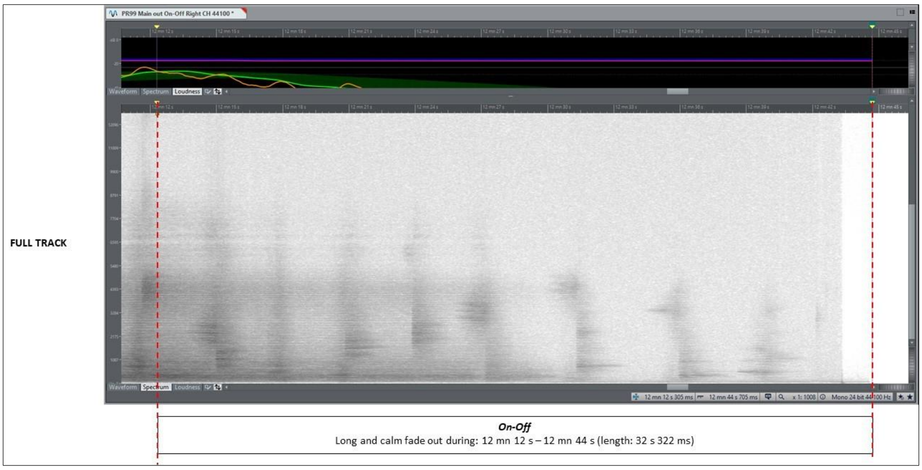


Figure 89. *On-Off* – a detail: the long and calm ending with the 30-second fade out (image: Ojanen)

7.1.3 Improvising within the studio

For the soundtrack of the TV documentary *Maan aurinko* (1968/70[390]) Salmenhaara used an octave arpeggiator to set the tempo and rhythmic pattern for the melody, played on a synthesizer. He realized the synthesized rhythmic pattern with the DIMI-A in 1970 – apparently very shortly before the broadcasting of the documentary.[391] A few details reveal something about the realization of this nine-octave arpeggio. The steady pulse of the up-and-down pattern suggests that the machine clock controlled the speed of the rhythm, and that Salmenhaara only performed the notes of the melody manually. This is revealed when the notes change: their onsets are not synchronized with the arpeggio but appear randomly in-between the steps (see Figure 90).

The soundtrack of the documentary film *Aggressio* (1968), which was never completed or released, provides another example of Salmenhaara's use of the studio as a real-time performance instrument. He fed the signal of pre-recorded music through the mixer back to the recoding tape recorder in *Aggressio*, producing repetitions with a distinctive rhythmic pattern and strong feedback. As is typical with this technique, the accumulating repetitions saturate and distort the signal against the tape. The effect is clearly audible in the segments of *Aggressio*.

[390] Ritavuori, Heikki 1970: *Maan aurinko*, see: https://areena.yle.fi/1-50096523, see also Ruohomäki (2020, EH34/14).
[391] See *Länsi-Savo* 17.10.1970, 10; "Musiikin on säveltänyt Erkki Salmenhaara käyttäen hyväkseen Erkki Kurenniemen juuri valmistunutta tietokonetta." (Engl. "The music was composed by Erkki Salmenhaara using Erkki Kurenniemi's newly completed computer.")

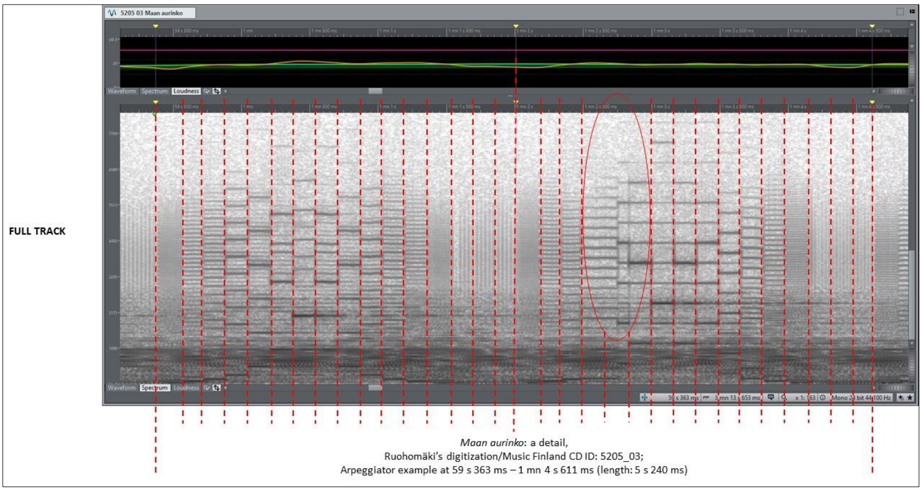


Figure 90. Synthesizer arpeggio in *Maan aurinko* (1968), the note changes not synchronized with the arpeggio (image: Ojanen)

Lindeman's use of improvisation and real-time instrument control as a compositional technique in his repertoire is interesting given that he turned from orchestral music to electronic music to gain control over his musical expression. Within the studio context, he utilized the DICO sequencer to produce sound fields in which individual notes lose their meaning. He used both the statically pulsating sequencer sound fields with no alteration of the instrument parameters, which he processed with filters, and smoothly modifying musical patterns, which he produced by altering the rapidly running 12-step sequencer of the DICO on the fly. Thus, he performed with the DICO in real time within the studio environment.

Lindeman took advantage of the DICO's programmable features – excluding the two-channel output. The instruments appear in his electronic works as a point source mono signal in either of the two channels, and they produce a dual-track mono output rather than a stereo field. Lindeman introduced his basic DICO techniques in his first work with the instrument. *Mobile* (1969), which he composed for the *Valo ja Liike 2* (Engl. Light and Movement) exhibition, consists of 14 segments with seven different themes – some of which are variations on previous patterns and typically appear as responses to each other in another channel: for example, the second segment (A') is an inversion of the first segment (A), their fast ostinatos run in opposite directions, and their volume contours and filtering are symmetrical and mirrored (see Figure 91). The DICO sequence is unaltered in the first two segments. Lindeman's real-time manipulation of the DICO's parameters is clearly visible in the left channel segment F: he reused the segments of *Mobile* in his other works. However, the DICO-centered real-time improvisation eventually conflicted with Lindeman's goal of having tight control over his material and he decided to abandon the solely DICO-based works.

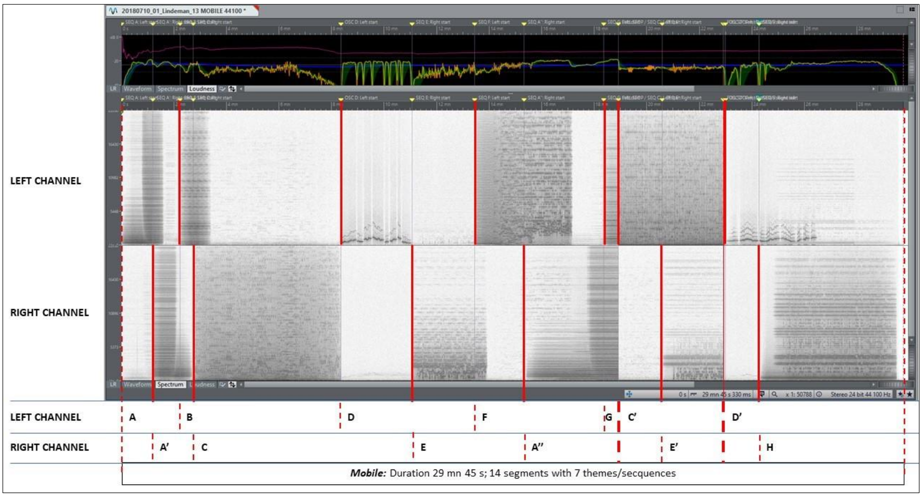


Figure 91. Lindeman *Mobile* (1969) consists of 14 segments with seven different themes. One very short segment – presumably the same that Lindeman used as the national TV News sound logo – is hidden just before D'. All the DICO sequences in *Mobile* are point source mono signal and only appear in one of the two channels. Thus, rather than producing a stereo field the work produces two individual channels, which was a suitable arrangement for the exhibition space. (image: Ojanen)

The real-time improvisation technique that Lindeman used with the DICO in the studio environment resembles the real-time sequencer manipulation in Nilsson's *Skorpionen* (1964/65; see Figure 92) and in Kurenniemi's *Antropoidien tanssi* (1968). The only difference between the three is that Lindeman and Nilsson first performed with the instruments, then compiled their works from several recordings with tape recorders. They partially overdubbed them, and processed the prerecorded material with a reverb, tape delay or filtering. Kurenniemi, in turn, produced *Antropoidien tanssi* completely as a real-time improvisation, and did not process or overdub the sound of the instrument afterwards. He only spliced three segments of tape to realize the final version (see Figure 93).

The soundtrack for Ruutsalo's film *Hyppy* (1965) provides a counterexample to the three works with real-time improvisation. Ruutsalo wanted a mechanical soundscape for his short film about routine workflow in a felt-boot factory, whereas Kurenniemi used the newly completed Integrated Synthesizer to produce eight static sequences with no modification of the instrument parameters – excluding the tempo changes in the last sequence (H; see Figure 94). Ruutsalo used all the sequences for the final soundtrack but rearranged their order and spliced them together with the picture (see Figures 94 and 95). The film features sequence (G) as its main theme, which appears seven times in the final soundtrack, whereas other sequences (from B to F) serve as short interludes in the main theme. The first sequence (A) serves as a theme for the longer middle section of the film. No recordings were processed afterwards, and in this respect the soundtrack resembles *Antropoidien tanssi*.

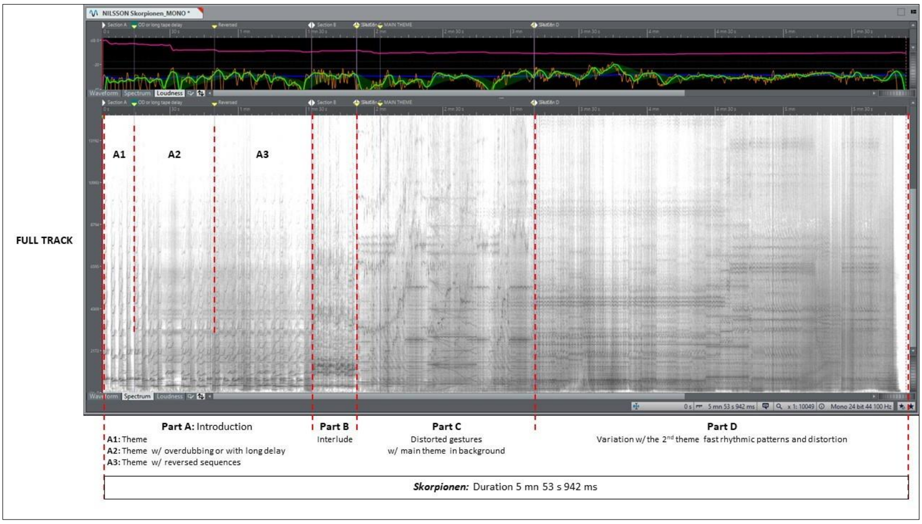


Figure 92. *Skorpionen* (1964/65) by Nilsson, with overdubbed prerecorded sound material and live manipulation of the Integrated Synthesizer parameters (image: Ojanen)

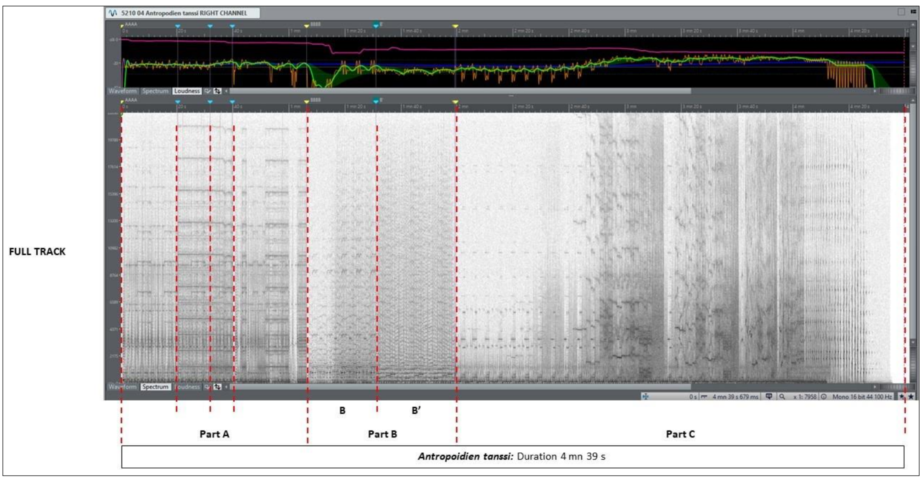
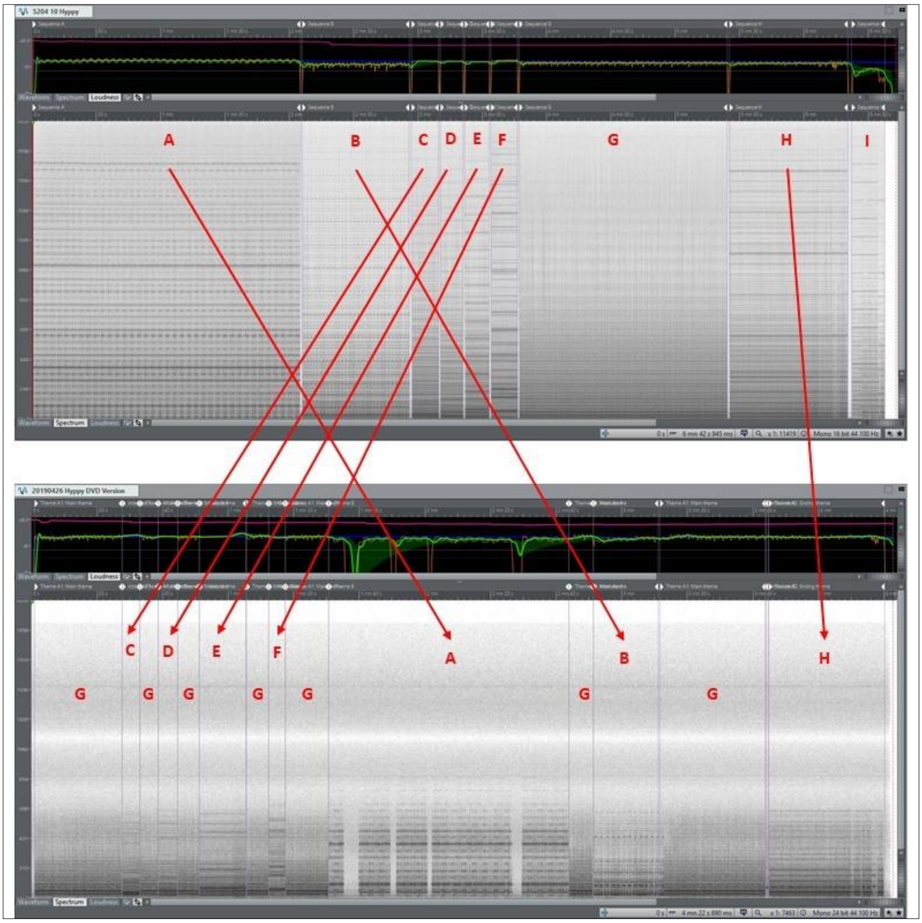


Figure 93. Kurenniemi recorded a tape, which he later used as his work *Antropoidien tanssi* (1968) to be released on a compilation album *Perspectives 68: Music in Finland*; he did this hastily before taking the instrument to Stockholm to Ralph Lundsten and Leo Nilsson, who had commissioned it. Kurenniemi realized the three segments of the work as real-time improvisations with the Andromatic in the studio environment. (image: Ojanen)



Figures 94 and 95. Kurenniemi produced eight static sequences (sections A to H) and one static chord (section I) with the Integrated Synthesizer (upper image) for Eino Ruutsalo's film *Hyppy*. Ruutsalo used all the sequences but not the chord in the final version of the soundtrack (lower image). (image: Ojanen)

7.1.4 Computer-metaphor-driven composition and music-production processes

The computer-metaphor-driven process, in other words the concept I use here as an analytical tool, is intertwined with definitions of the computer, but it does not call for one specific unequivocal definition of a computer per se. A machine capable of automated processing qualified as a (analog) computer in the 1960s and 1970s, even though it was not capable of association or of making decisions. According to Kurenniemi (in 1971), the line between a computer and a non-computer depended on the machine's capacity for drawing conclusions; a programmable shift register, in other words a musical sequencer, did not equate it to a computer. Herein lies a hint that at the time he was anticipating something that is known today as artificial intelligence.[392] Thus, Kurenniemi's utopian visions were not at the composers' and artists' disposal, even though were eagerly anticipated.

Kurenniemi's first sequencers, from the Integrated Synthesizer (1964) to the Andromatic (1968), did help to automate music production. However, as is evident from the works completed with the instruments, they were based on real-time performance and improvisation with the instrument rather than on a computerized composition process. The performed or improvised sound material was first recorded on tape and then processed further using tape-manipulation techniques – or in some cases it was used without further processing.

Kurenniemi's long-term aim was to build the University Studio as a computerized entity, but this was never realized. Elements of a computer-metaphor-driven composition process were present in *On-Off*, but only in the sympathetically entitled name of the work. James Tenney, on the other hand, who was one of the pioneering composers of computer music, used a stored-program computer, IBM 7090, in his *Analog #1: Noise study* (1961). The parameter input of the Integrated Synthesizer was approximate, and the instrument could not be programmed with precision. Nevertheless, Kurenniemi was path-dependent and continued the development directed by his computer-metaphor-driven goal. After the Sähkökvartetti (1968) and the Andromatic (1968), he realized such a design for the first time in the DICO (1969) and the DIMI-A (1970), both of which can be programmed with precision (see Chapter 6).

These instruments advanced Kurenniemi's designs in significant steps and he was able to avoid the painstaking task of tape splicing. However, the instruments only provided psychomotor extensions that helped the composer to automate the playing and performing, rather than cognitive extensions that could have lightened his or her mental burden. The non-visual and non-descriptive user interfaces load the composer's memory rather than facilitating the composition process. Users wishing to program the instruments need a copy of the instrument's memory content in their own minds – even if it has been written down on paper, as Lundsten states in his notes on the DIMI-A, which resemble the scores used in the tracker software of the 1980s (see Figures 96 and 97; Lassfolk et al. 2015, 268). With practice, however, simple sequences were relatively easy and fast to program into the instrument, as Ruohomäki showed in his demonstration of *Sähköinen tapahtuma Vanhalla*, and Lundsten with his boogie-woogie programming example.[393]

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[392] Leino (1971, 35); see also Nilsson (2019) in an interview with Ojanen.

[393] See the DIMI-A boogie-woogie example in Sima, Jonas (1973). *Cosmic Love. Ralph Lundsten elektrontonsättare*; Ett porträtt av Jonas Sima. http://www.svenskfilmdatabas.se/sv/item/?type=film&itemid=56455; http://www.sima.nu/film-cosmic.htm

There is no surviving documentary evidence of the optical input of the DIMI-O being used to read graphical scores, which was one of its initial design goals, and is not known to be employed.[394]

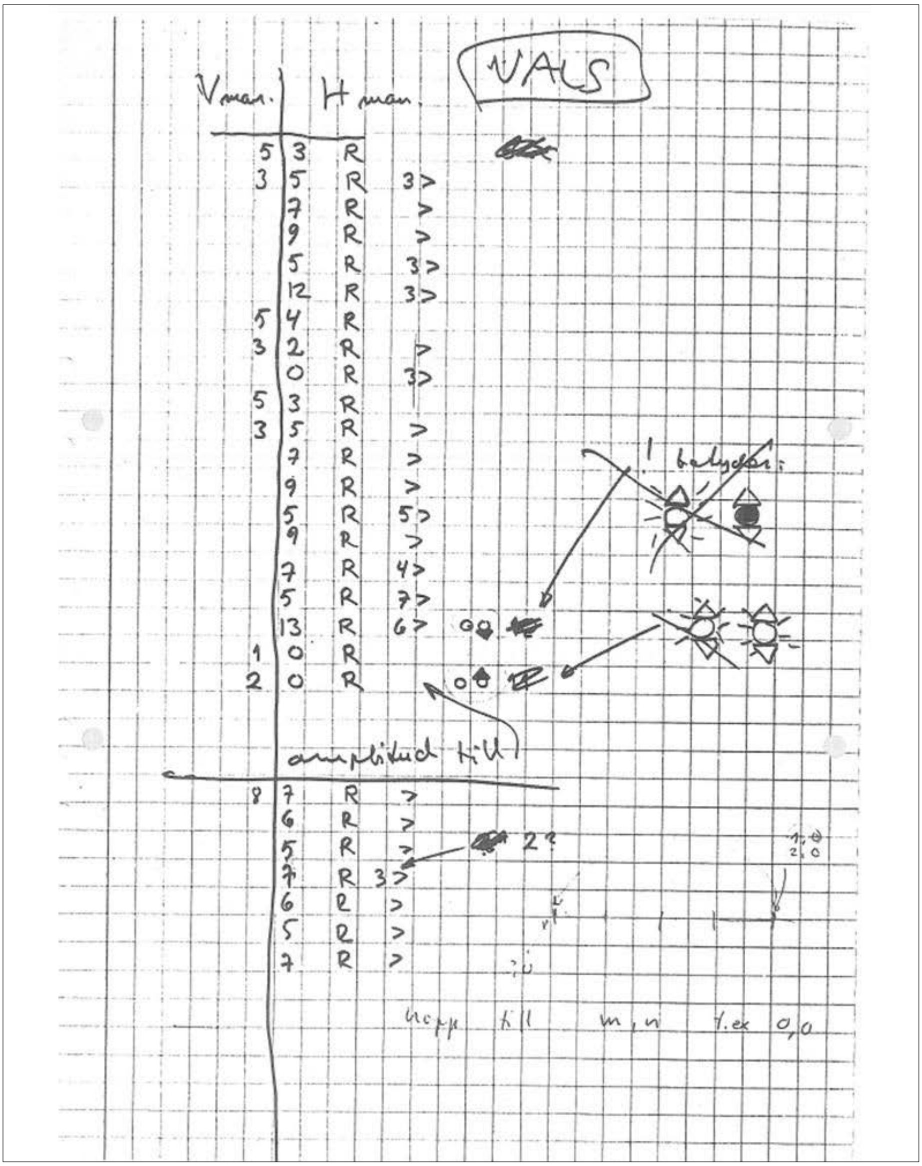

Figure 96. Handwritten score draft for the DIMI-A by Ralph Lundsten (image: The Documentation of the DIMI-A/UHMRL archive)

394 A typical demonstration of the instrument is exemplified Lundsten in the Swedish magazine program *Kika-Digga-Ding* from 1975; see: https://www.youtube.com/watch?v=VfDr9zaO_TQ

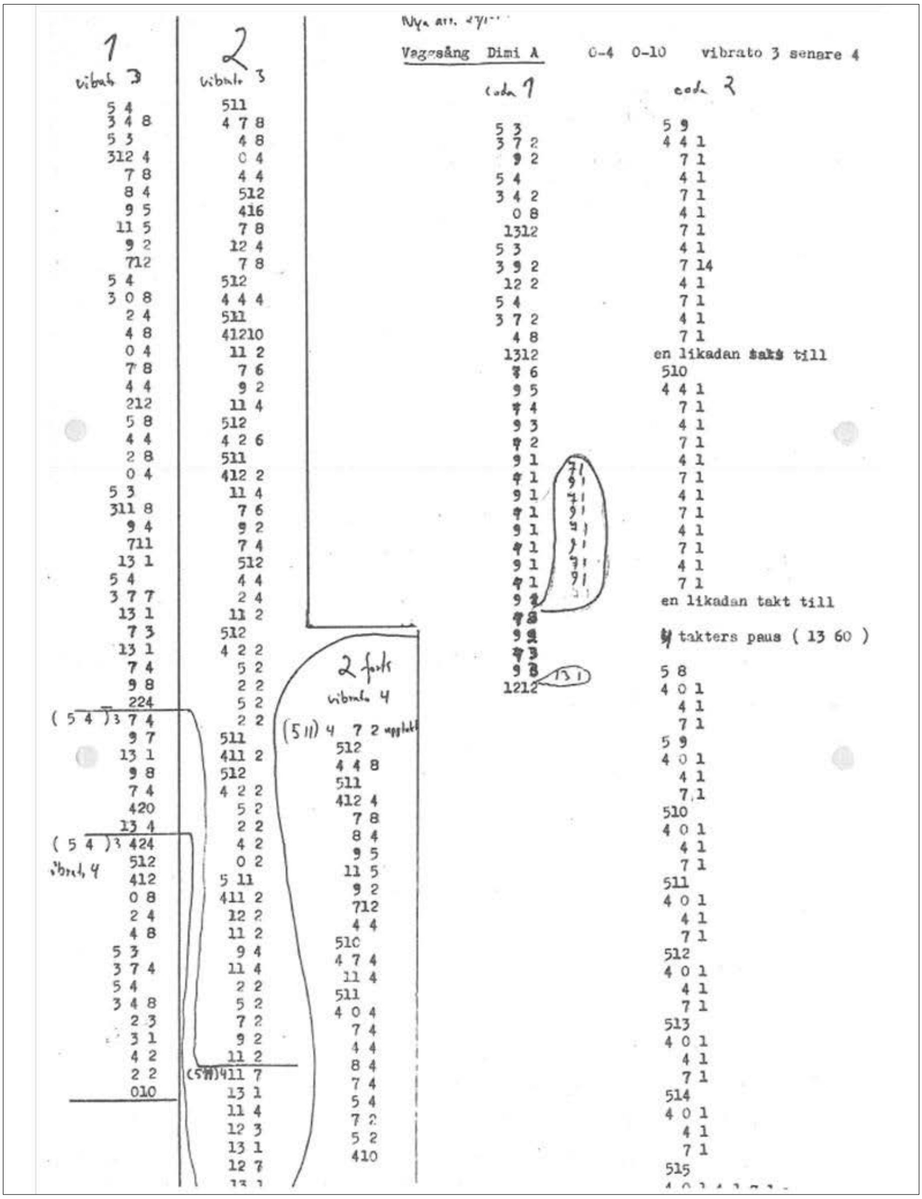

Figure 97. Typewritten score drafts for the DIMI-A by Ralph Lundsten (image: The Documentation of the DIMI-A/UHMRL archive)

The DICO's limited sequencer and memory capacity (only four programmable parameters on 12 steps) did not encourage Lindeman to use the instrument to compose prescribed note-based musical sequences (see Riikonen 1978). A detailed note-based analysis of his works is not feasible because he used the DICO to produce fast arpeggios, in which the individual notes were part of the dense sound field rather than produced melodic themes. Lindeman typically used the short sequence as a point of departure for the production of raw sound material. Even if he did program the initial sequence according to his plans, he then modified it in real time to produce slowly morphing musical passages, which he first recorded on tape and then compiled into a work.

The DIMI-A, on the other hand, encouraged composers to concentrate on programming the instrument. However, its low memory capacity forced them to program and record their works in short fragments, which they then compiled on a tape recorder to form a complete work. This hurdle directed the use of the instrument along the path of computer-metaphor-driven composition: its programmability took precedence over real-time performance.

For *Mikä aika on* (1970) Ruohomäki programmed the DIMI-A to play musical sequences especially dominated by the bass ostinato, which anticipates riff-driven music styles such as the synthesized disco that was emerging during the 1970s, along with works by Giorgio Moroder and the German group Kratfwerk. He programmed melodic sequences and sound gestures over the rhythmic background driven by the bass ostinato. All the material was then synchronized using tape recorders (see Figure 98). *Mikä aika on* exemplifies how the limits of the instrument's memory capacity forced Ruohomäki to return to time-consuming tape manipulation. It took a considerable amount of time to realize the work, and Ruohomäki recalls Kurenniemi's concern about whether he could produce it in time to be issued on the DIMI-A promotional record (*Dimi is born*, 1970).[395]

The computer-metaphor-driven use of the DIMI-A features in a few synthesized arrangements of classical music works – specifically Johann Sebastian Bach's inventions. To demonstrate the potential of the two-voice instrument Kurenniemi programmed Bach's Invention 13 in A minor with it, entitled and published as *Inventio* (1970). Ruohomäki programmed Bach's Invention 1 in C major, and a few years later Heikki Valkonen used the instrument in a similar way in his realization of *Le Coucou* (1977) by Louis-Claude Daquin.

Given the limited memory capacity of the DIMI-A, Kurenniemi had to program the Bach Invention in parts. First, he programmed two bars into the instrument, and then recorded the segment on tape. Starting from the fourth tape segment he only programmed one bar, and recorded that on tape: in total the Invention is programmed in 22 parts and recorded on 22 tape segments, spliced together to form a complete work (see Figure 99; for an overall analysis of the arrangement see the data set;[396] see also Lassfolk et al. 2015, 269–271).

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[395] Ruohomäki (2018) in an interview with Ojanen.

[396] See Ojanen (2018[2015]): *Arrangement of J.S. Bach's invention in A minor (BWV 784) for the DIMI-A synthesizer by Erkki Kurenniemi (1970): An annotated video of the master tape* at: http://doi.org/10.5281/zenodo.1469722; Video publication: https://vimeo.com/278832133

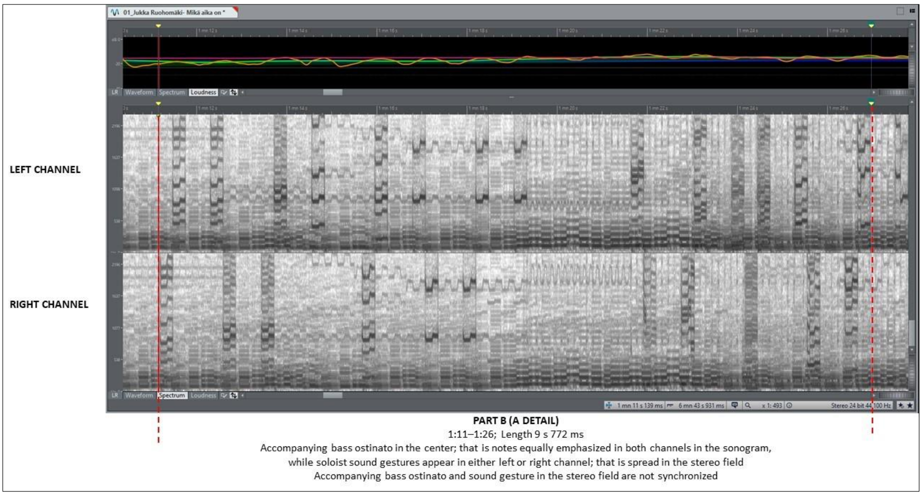

Figure 98. A detail of the analysis of *Mikä aika on* (1970). Ruohomäki compiled it from several separately recorded DIMI-A sequences, which he then laid upon each other using tape recorders. Here, the soloist sound gestures spread in the hard left and right in the stereo field are accompanied by static bass ostinato, equally emphasized in both channels. The soloist gestures and the accompaniment are synchronized using tape recorders, thus the onsets are not precisely aligned. (image: Ojanen 2019)

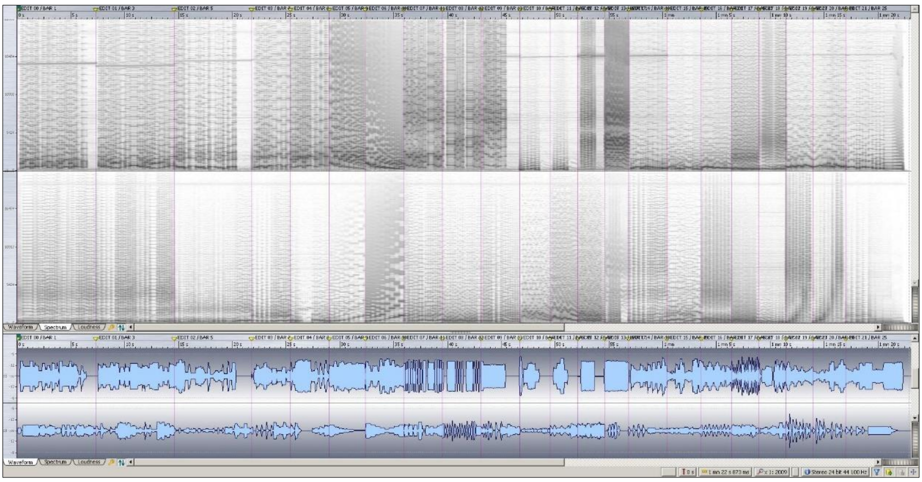

Figure 99. Kurenniemi's (1970) arrangement of Johann Sebastian Bach's *Invention* No 13 in A minor for the DIMI-A. Due to its memory capacity, Kurenniemi had to program the arrangement in 22 segments, and splice the tape segments together to form the final version. (image: Ojanen 2018[2015])

Unlike Ruohomäki's *Mikä aika on*, Kurenniemi's Bach rendition does not consist of overdubbed sounds, but Bach's two-voice Inventions yield suitable material for a two-voice instrument to be programmed and recorded a whole segment at a time. Wendy Carlos's Bach arrangement realized with a Moog system (*Swithed-on Bach*, 1968) differs in that Carlos performed and played the instrument parts with the instrument and then recorded them on a multi-track tape recorder, with several overdubs.[397]

The first half of Kurenniemi's arrangement is straightforward, note-by-note programming with only a little alteration of other parameters of the instrument. Towards the end, he started to insert other than note data into the sequencer. The computer metaphor directed the design of the DIMI-A to such an extent that Kurenniemi did not build an envelope generator into it, indicating that everything should be programmed. Therefore, each parameter has to be programmed separately when tempo changes, dynamic variation, note articulation or coloration are added to the musical output.

Kurenniemi stretched the initial sequencer infrastructure to implement a dynamic variation into single notes, which suggests 16 bars with 16 beats, the minimum length of 16th-note-duration programming. When he programmed a dynamic variation into 16th notes he employed the 256 steps of the sequencer to produce only four bars with 64th-duration values for each note. Here, one 1/16 note occupied eight steps of the 256-step sequencer, during which different filter or amplitude values could be programmed, even to the shortest notes (see Figure 100).

A comparison of the different arrangements of Bach's Inventions for the DIMI-A and Daquin's *Le Coucou* reveals the different programming strategies of DIMI-A users. Ruohomäki did not alter the tempo in his arrangement of Bach's Invention No. 1 in C major, generally settling for programming the note data. The rare variation in the sound is the dynamic alteration in bar 12 when he used a similar technique to the one adopted by Kurenniemi (see Figure 101). Otherwise Ruohomäki's arrangement is static. Only a few audible snaps due to tape editing and an extra 1/16 note in the third bar are perceivable unintentional sound gestures.

In his arrangement of Louis-Claude Daquin's *Le Coucou* Heikki Valkonen followed Daquin's score more closely than Kurenniemi or Ruohomäki followed Bach's instruction – which does not dictate the tempo or the dynamics, however. Valkonen processed the final version with a subtle reverb that hides the tape splicing. Valkonen's master tape is not similarly spliced as Kurenniemi's, therefore no detailed structural programming segmentation is possible. A few interesting details emerge from Valkonen's master tape, however. Daquin's score consists of dynamic and tempo changes such as seven ritardandi, which Valkonen follows, and volume changes in his performance instructions. (see Figures 102 and 103)

[397] See the sleeve notes in Carlos, Walter (1968): *Switched-On Bach*. Columbia Masterworks – MS 7194. https://www.discogs.com/Walter-Carlos-Switched-On-Bach/release/1308287

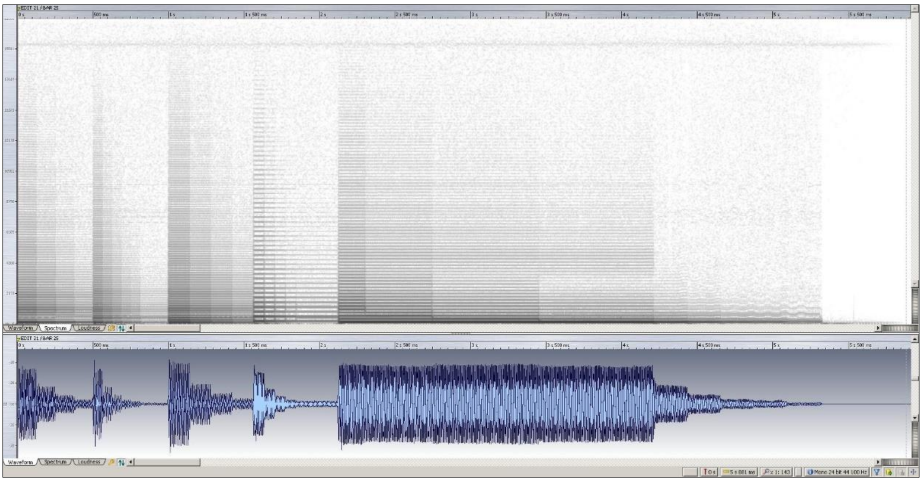

Figure 100. A programming example of Kurenniemi's (1970) arrangement of Johann Sebastian Bach's *Invention* No 13 in A minor for the DIMI-A; the dynamic contour for each note programmed with closing bands of the filter bank step by step with 1/64-time values at the end of the work on the right-hand part in bar 25 (image: Ojanen 2018[2015][398])

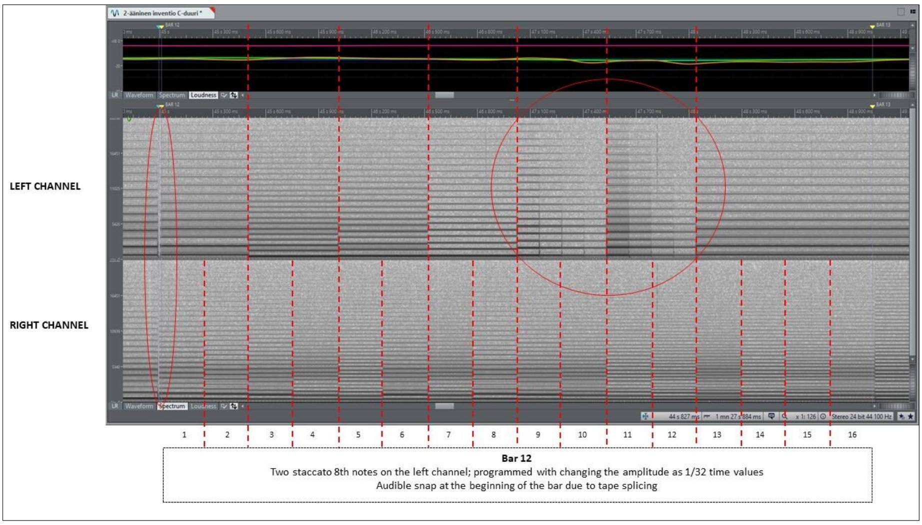

Figure 101. A programming example of Johann Sebastian Bach's *Invention* in C major arranged for the DIMI-A by Ruohomäki (1970); the dynamic contour for two notes in bar 12 programmed by adjusting the volume parameter with 1/32-time values (image: Ojanen 2019)

[398] See Ojanen (2018[2015]): *Arrangement of J.S. Bach's Invention in A minor (BWV 784) for the DIMI-A synthesizer by Erkki Kurenniemi (1970): An annotated video of the master tape* at: http://doi.org/10.5281/zenodo.1469722

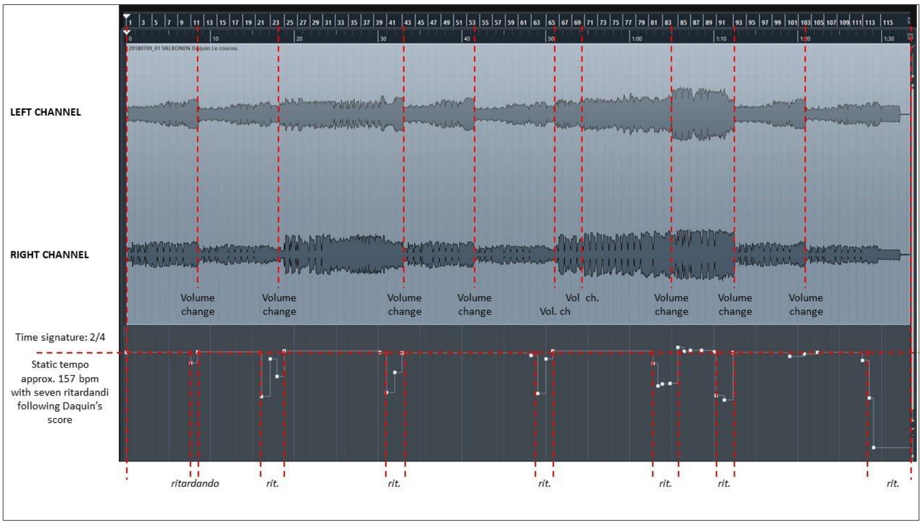

Figure 102. Programming example of the arrangement of Louis-Claude Daquin's *Le Coucou* for the DIMI-A by Heikki Valkonen (1977): The dynamic and tempo variation (image: Ojanen 2019)

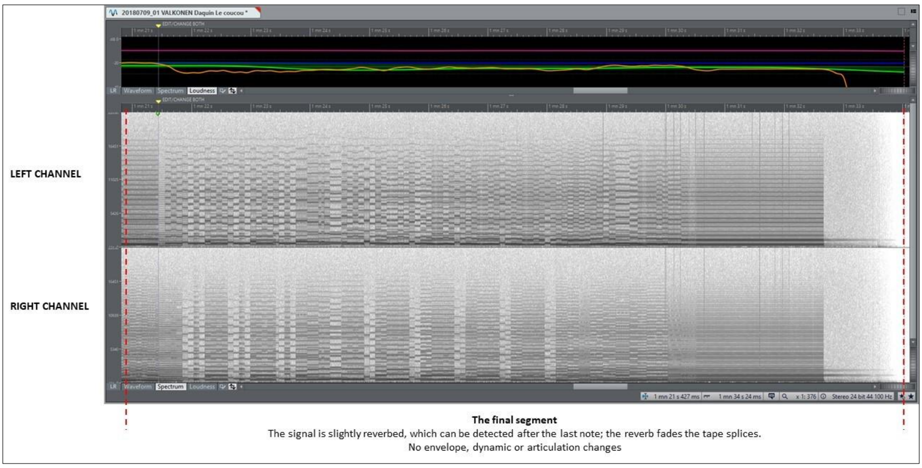

Figure 103. A programming example of Heikki Valkonen's (1977) arrangement of Louis-Claude Daquin's *Le Coucou* for the DIMI-A: no dynamic, modulation or coloration alteration in the final segment of the work – especially not in the last note; cf. the last note in Kurenniemi's arrangement (see Figure 100; image: Ojanen 2019)

Ruohomäki and Vesterinen found another interesting computer-metaphor-driven use for Kurenniemi's instruments in their children's radio play *Sähkölintupuutarha* (1971, Engl. The Electric Birds' Garden). Both the play and a short film were realized in collaboration with Vesterinen. In an interview with Paavolainen[399] they give a detailed description of the techniques they used in their search for the sounds for the work. At the time, when computers for composition and music production were not available in Finland, the composers were not able to realize works based on extensive mathematics-based signal processing, such as those relying on stochastic techniques developed by Greek-French composer Iannis Xenakis in particular. To overcome the challenge, Ruohomäki and Vesterinen made innovative use of the optical input and the threshold of the luminance control of the trigger (bang-bang) circuit of the DIMI-O. To produce stochastic sound gestures for *Sähkölintupuutarha*[400], in which they wanted to imitate the random chirping of the chicks, they directed the DIMI-O camera towards the moving clouds, the movements causing subtle changes in the lighting and thus triggering the notes of the instrument stochastically.[401]

7.1.5 Sequencer-based examples

The first sequencer designs could not live up to the expectations of computer-metaphor-driven processes, therefore composers and artists were forced to rely on tape-manipulation techniques. However, there are a few examples of how users facilitated the process by using sequencers innovatively: Eero Koivistoinen with his music album for children *Ruusa ja Muusa* (1971); Donner with his music for the radio play *Vihreä eläin* (1971); and Ruohomäki with Sakari Lehtinen and Heikki Harma from the folk group Cumulus on the track *Sirkuksen seinillä* (Engl. On the Walls of the Circus) from its third album *Sirkustirehtöörin pieni sydän* (1973; Engl. The Little Heart of the Ringmaster). All these works exemplify studio-based workflows in the context of popular music.

Jazz musician and composer Eero Koivistoinen used electronic means on his children's music album *Muusa ja Ruusa* (1971, Engl. Muusa and Ruusa), which is based on the poems of well-known Finnish poet Kirsi Kunnas. He used the DIMI-O sequencer on the track entitled *Sammakkojen ulosmarssi* (Engl. The Walkout of the Frogs), which allows the altering of sequence contents in real time. The track is in two parts, the first part (Part A: Bars 1–34) using the DIMI-O sequencer. The basic sequence, which runs throughout the part, consists of a simple two-bar melody and its DIMI-O-realized accompaniment (see Figure 104). The first half of the 34-bar section comprises the simple sequence with additional tonal notes appearing from the ninth bar onwards. Koivistoinen gradually added atonal and modulated notes such that towards the end the rhythmic cluster dominates as the original melody and chord structure almost vanish in the chaotic sound field realized with modulated atonal notes and spread in the stereo field with a tape delay. Koi-

[399] See Vesterinen and Ruohomäki (1971) in an interview with Paavolainen.
[400] See the Elonet database: https://elonet.finna.fi/Record/kavi.elonet_elokuva_153068
[401] Ibid.

vistoinen may have overdubbed the sequences with the tape recorder. Starting from bar 15, the onsets of the added notes are not precisely synchronized with the original DIMI-O sequence and have different modulation (i.e. vibrato). Moreover, not all the added notes fit the 32-step resolution of the DIMI-O sequencer, and a more finely grained sequencer would have been needed. The DIMI-O part of the track ends with the sound of crashing objects and a door slamming with a distinctive reverb. The track exemplifies the use of the DIMI-O sequencer as a real-time programmable barrel organ.

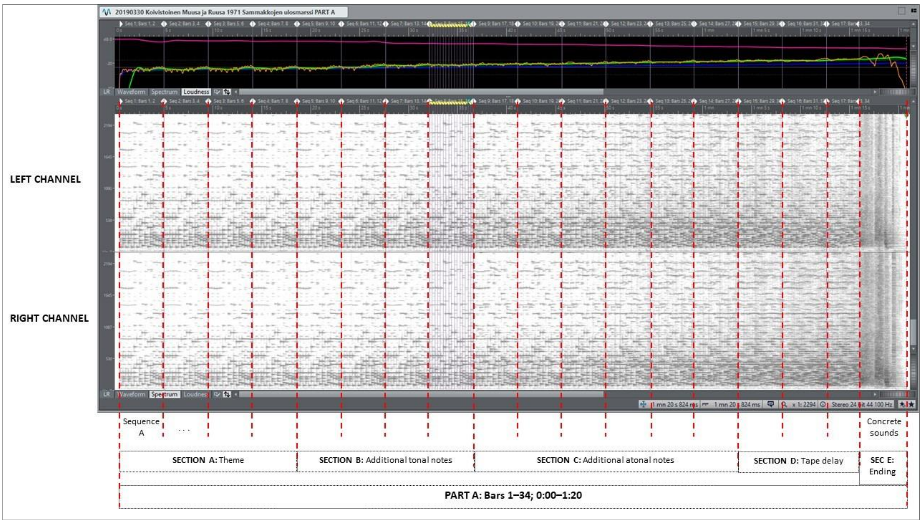

Figure 104. The DIMI-O sequence used on the track *Sammakkojen ulosmarssi* by Eero Koivistoinen. The barrel-organ sequence is slowly modified by adding first tonal notes in real time (Section B), then atonal notes with frequency modulation (Section C), eventually leading to the chaotic cluster spread in the stereo field with a tape delay (Section D). The first part of the track (Part A), produced solely with the DIMI-O and tape recorders, ends with an explosion produced with a distorted concrete sound gesture resembling the slamming of a door. (image: Ojanen 2019)

Kurenniemi's instruments play a significant role in the radio play *Vihreä eläin* (1971), which is based on Vesterinen's text and Donner's music and sound design. Together with Vesterinen (Sähkökvartetti[402]), Ruohomäki (DIMI-A) and Kurenniemi (DIMI-O), Donner recorded the parts with Kurenniemi's instruments first. The narrator's role and the other instruments were recorded later in another session. Donner utilizes the Sähkökvartetti sequencer in three parts of the play to produce an accompaniment and a metronome for the music performed by the Otto Donner Treatment jazz group. The third part of *Vihreä eläin* (3:10–5:03; see Figure 105) opens with

[402] Some of the Sähkökvartetti and DIMI-A parts were released on Kurenniemi's compilation CD *Äänityksiä/Recordings 1963–1973* in 2002 under the track titles *Sähkösoittimen ääniä #1* and *#4*. On the CD the tracks are credited to Kurenniemi and the DIMI-A track is introduced as the Sähkökvartetti recording. *Vihreä eläin* is not mentioned as the origin of the sound material.

the Sähkökvartetti bass drum with bongo and clave sounds added one after another every four-bar cycle, with an approx. 81 bpm tempo. Starting from the ninth bar, Otto Donner Treatment comes in gradually, first with the double bass (bar 9), then the brass section with long notes (bar 13) and finally the whole group with the saxophone solo (bar 17).

Thereafter the tempo accelerates rapidly within two bars (17–19), from 81 to approx. 105 bpm. The accelerando, which Otto Donner Treatment follows closely in the overdub recording session, was performed earlier by Sähkökvartetti in real time, the master tempo of the sequencer being adjusted.[403] The narrator comes in at 4:25 and the DIMI-A at 4:34, mimicking *Vihreä eläin* with random staccato pitches spread in the left and right channels as a point source dual mono signal employing the two-channel output of the instrument.

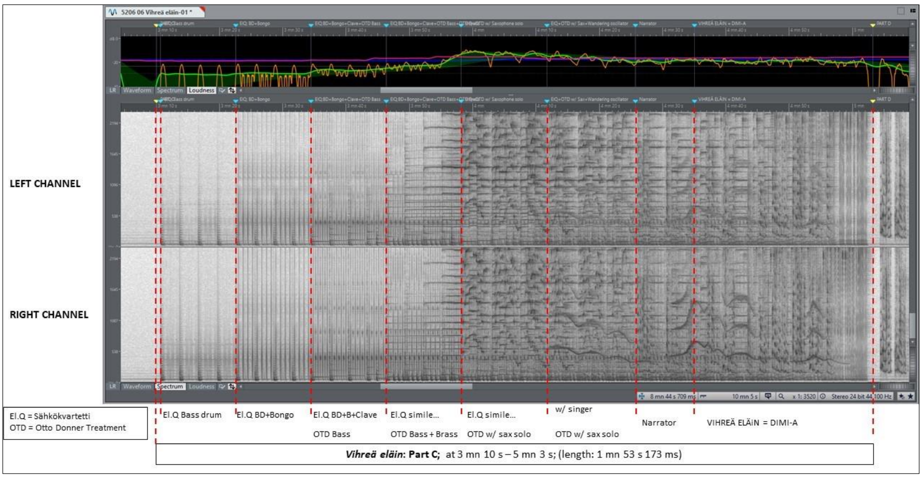

Figure 105. The Sähkökvartetti provided an accompaniment and a metronome for the other instruments in three parts of the radio play *Vihreä eläin* (1971; image: Ojanen 2019)

In 1973, Ruohomäki used the DIMI-A sequencer to accompany Sakari Lehtinen's song *Sirkuksen seinillä* (Engl. On the Walls of the Circus) in the album *Sirkustirehtöörin pieni sydän* (1973; Engl. The Little Heart of the Ringmaster) released by the folk group Cumulus. Lehtinen and Heikki Harma (also known as Hector, singer and songwriter with Cumulus and Ruohomäki's old school mate) came to the University Studio to meet Ruohomäki and to record sounds from the DIMI-A.[404] Ruohomäki had never heard the song, but Lehtinen asked him to produce sounds with it that were recorded

[403] The tempo change can be detected on the track *Sähkösoittimen ääniä #4* on Kurenniemi's compilation CD *Äänityksiä/Recordings 1963–1973*, which the original radio-play session recording without the latter overdubs.

[404] Ruohomäki (2018) in an interview with Ojanen; see also Karlsson and Lehtinen (2018) in an interview with Riihimaa.

on a tape.[405] It is not known what state the song was in at the time the rhythmic pattern was recorded, nor the extent to which the DIMI-A pattern influenced the final arrangement. Other instruments on the track were recorded on top of the DIMI-A's rhythmic pattern (see Figure 106) later in the Finnvox studio.

Here, the DIMI-A served as a metronome for the entire track, even though it can be heard in only a few parts in the final album version. Its sound gestures appear on the left channel, starting from the first instrumental part (part C) and on the right channel during the instrument parts (C, F, and H). After the intro part with a lower tempo (63 bpm), the tempo of the track is fixed to approx. 112 bpm (see Figure 107), following the tempo of the DIMI-A sequence. In contrast to *Vihreä eläin*, here the tempo of the instrument serving as a metronome was static. Ruohomäki also utilized DIMI-A's precisely adjustable clock in film work in which synchronization management was crucial.[406]

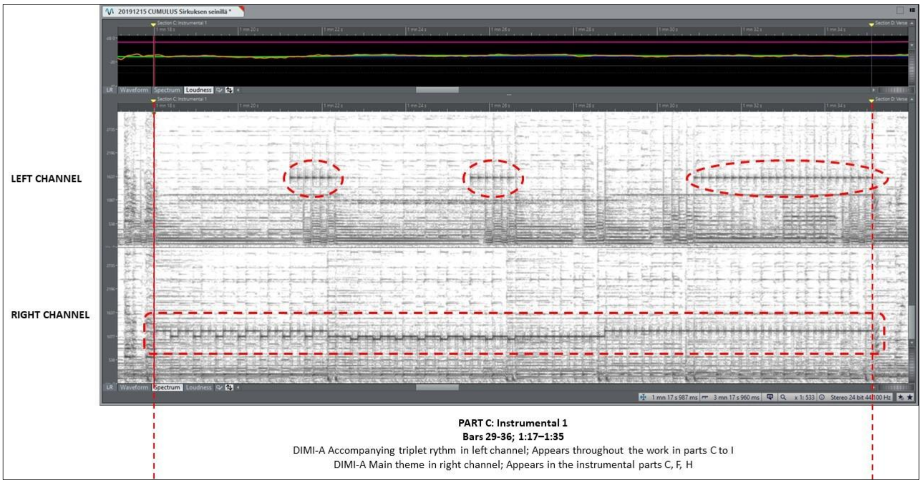

Figure 106. A detailed view of Part C in which the DIMI-A sound gestures first appear: those on both channels are precisely synchronized, which supports the interpretation that they were produced with the DIMI-A in one take (image: Ojanen 2019)

405 Ruohomäki (2018) in an interview with Ojanen.
406 Ibid.

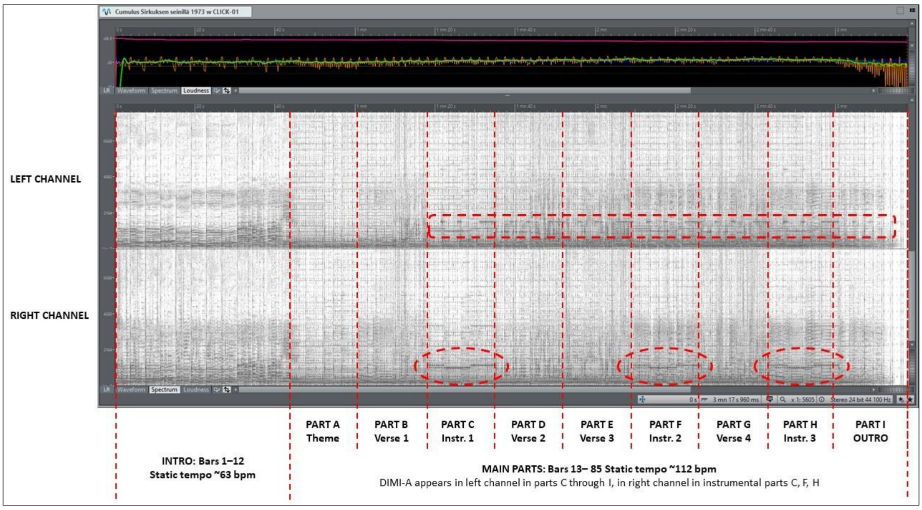

Figure 107. The DIMI-A triplet pattern providing a temporal frame for the track *Sirkuksen seinillä*. The sound gestures are visible in the sonogram – the static tempo throughout the track supports the interpretation that the DIMI-A was recorded first, providing a metronome for the track, and the rest of the instruments were recorded later on top of the DIMI-A rhythmic pattern. On the final album version the DIMI-A pattern appears continuously on the left channel starting from part C, and during the instrumental parts (C, F, and H) on the right channel. (image: Ojanen 2019)

7.1.6 Sound synthesis examples

The waveform of Kurenniemi's instruments was mainly square, and most of them included filters. The alteration in sonic character was to be produced with subtractive synthesis via filtering the harmonic structure of the sound.

Ruohomäki's works *Adjö* (1974; Engl. Farewell) and *Ennen iltaa* (1977; Engl. Before Evening) exemplify how to broaden the synthesis potential of Kurenniemi's computer-controlled designs. Ruohomäki used the DIMI 6000 in *Ennen iltaa* to produce rising chromatic sequences. He first programmed several four-note sequences with the instrument, and then he overlaid the recordings on top of each other to achieve a chaotic cluster in which the single notes lose their meaning and the cluster forms a pulsating sound field with a rich timbre (see Figure 108). Here, the DIMI 6000 provided the means for producing masses of sound material, which otherwise would have required extensive resources. A similar sound field with a tonal minimalistic synthesizer arpeggio – typically in a major key or on a pentatonic scale – can be found in his works from the 1970s. Three years prior to *Ennen iltaa*, Ruohomäki used the DIMI-A and the DIMI-O to produce a synthesized sound field that had a strong association with nature. In *Adjö*, he employed sound material from the radio play and animated film *Sähkölintupuutarha* (Engl. The Electric Bird Garden), which explains the nature associations. He said later on that he found his own musical language in *Adjö* (see Ojanen 2014b, 163). In the third part of the work, the DIMI-O provides a static, minimalistic synthesized accompaniment for the several DIMI-A sound gestures, starting with a deep pitch bend. (see Figure 109)

Composer Andrew Bentley, who is especially interested in sound synthesis, employed the DIMI 6000 in *Bowing* (1978). His point of departure for the work was the rich timbral spectrum of the violin bow, and here he specifically aimed "to bring synthesis to a level that is timbrally sophisticated and satisfying to the ear."[407] Bentley produced most of his raw sound material in the York studio in which he worked and studied before moving to Finland in 1976.[408] He did not find the DIMI 6000 very easy to use, or flexible enough for sound synthesis, and said that the instrument "was used for only small parts of" the work.[409]

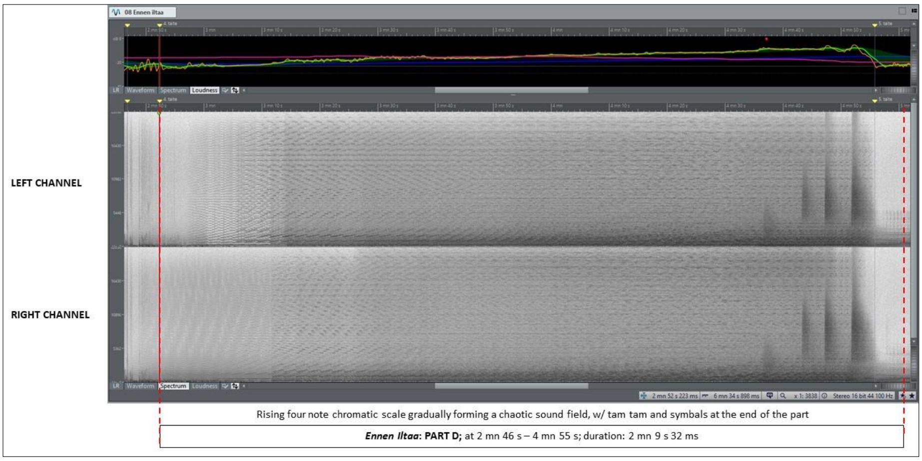

Figure 108. The DIMI 6000 cluster of chromatic sound field in Ruohomäki's *Ennen iltaa* (1977; image: Ojanen 2019)

[407] See Bentley (March 3, 2017): Historical electronic music by Andrew Bentley 2. https://algorithmicsound.com/2017/03/03/historical-electronic-music-by-andrew-bentley-2/
[408] Bentley (2015) in an interview with Ojanen & Lassfolk.
[409] See Bentley (March 3, 2017): Historical electronic music by Andrew Bentley 2. https://algorithmicsound.com/2017/03/03/historical-electronic-music-by-andrew-bentley-2/

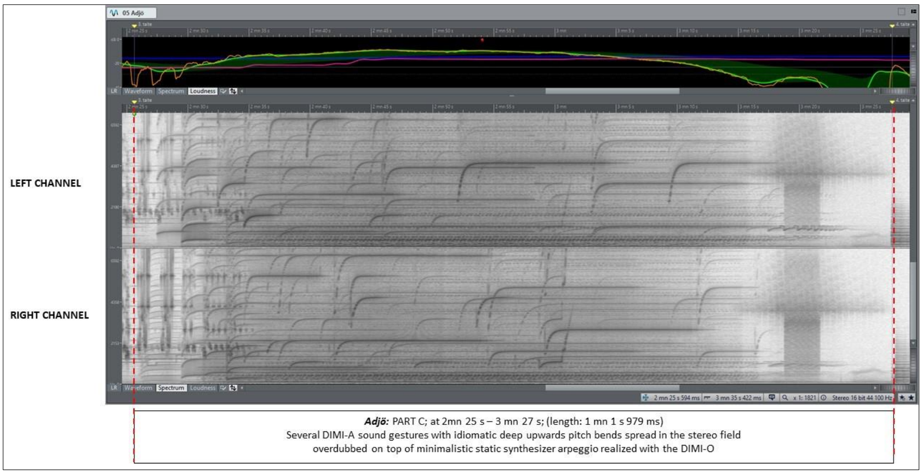

Figure 109. The DIMI-A and the DIMI-O provided sound sources for a fully synthesized sound field with a strong association with nature in Ruohomäki's *Adjö* (1974): in the third part of the work the DIMI-O provides a static minimalistic synthesizer arpeggio accompaniment for the several sound gestures, with deep upward pitch bends realized with the DIM-A (image: Ojanen 2019)

7.2 Outside the studio environment

Beyond the studio environment of electroacoustic music, there is an interesting distinction between live performance with electronic instruments and concert performances of standalone tape music work. After briefly discussing this distinction I will present my analyses of the appearance of these instruments in three categories: 1) live performances with Kurenniemi's instruments, 2) instrument tests and demonstrations, and 3) collective performances with Kurenniemi's instruments.

Kurenniemi's instruments rarely appeared in front of live audiences during the time frame of this study. Events during 1961–1978 identified thus far include the following: seven instruments were played in less than 30 live performances – usually only once with a certain instrument, with the exception of Sähkökvartetti (the band), which tops the list of known performances with the Sähkökvartetti (the instrument) – six instruments were demonstrated to the general public in twelve events, and three instruments were displayed in six exhibitions (see Table 7).

The list of events is not definitive, and more will be discovered in the future. Kurenniemi frequently presented his new prototypes, especially in the heyday of the DIMIs starting from 1970. More documentary evidence of instrument demonstrations is also likely to emerge from the archives. However, I believe that the saturation point of the research material has been reached, and that credible arguments can be based on these examples.

Unfortunately, most of these events were not recorded and the surviving documentary evidence is sparse, consisting only of casual mentions in magazine articles or some newspaper reviews. Therefore, closer analysis of how the instruments were used in most of the events is impossible. The events I describe and analyze in the following are those on which there is enough surviving documentation and that lie within the scope of this study.

Table 7. A summary of the appearances of Kurenniemi's instruments in front of a live audience, i.e. live performances, exhibitions and demonstrations at which the instruments were present, in chronological order: the updated list[410] is available in the Electronic Musical Instruments by Erkki Kurenniemi Zenodo community

Event	**City/Country**	**Date**	**Instrument(s)**	**Type of appearance**
Algorithmic music seminar / Jyväskylän Kesä	Jyväskylä/Finland	July 7, 1965	Integrated Synthesizer	Demonstration
Machine poems / Sähköshokki-ilta	Helsinki/Finland	February 9, 1968	Integrated Synthesizer	Live performance
Sähkökvartetti performances / approx. 15 performances	Sofia/Bulgaria; several locations/Finland	August 1968 to November 1970	Sähkökvartetti	Live performance
Den Immateriella Processen exhibition	Stockholm/Sweden	Opening on November 10, 1968	Andromatic	Exhibition
Feel It exhibition (preview)	Stockholm/Sweden	December 1968	Andromatic	Exhibition
Feel It exhibition	New York/United States	January 24 to March 16, 1969	Andromatic	Exhibition
Expo Norr exhibition	Östersund / Sweden	June 28 to July 6, 1969	Andromatic	Exhibition
Yle seminar on electronic music	Helsinki/Finland	November 5, 1969	DICO	Demonstration
Elektrononstop 1969 / Electronic music concert	Helsinki/Finland	November 17, 1969	Andromatic; DICO	Demonstration
Elektrononstop 1969 / Electronic music concert	Helsinki/Finland	November 17, 1969	Andromatic; DICO	Live performance
Nuorison taidetapahtuma 70	Turku/Finland	October 30, 1970	DIMI-A	Demonstration
Elektrononstop 1970 / Electronic music concert	Helsinki/Finland	November 17, 1970	DIMI-A	Demonstration
Elektrononstop 1970 / Electronic music concert	Helsinki/Finland	November 17, 1970	DIMI-A	Live performance
Digelius marketing event	Helsinki/Finland	January 20, 1971	DIMI-A	Demonstration
Ung Nordisk Musik 1971	Helsinki/Finland	February 10, 1971	DIMI-A	Demonstration
Intermedia, Elonkorjuupäivät / Elonkorjaajat festival	Helsinki/Finland	May 26, 1971	DIMI-O	Live performance
Dimi-musiikkikone / Pori Jazz	Pori / Finland	July 16 to 18, 1971	DIMI-A or O?	Demonstration
DIMI Ballet for TV (**NB**! not aired at the time)	Helsinki/Finland	September 22, 1971	DIMI-O	Demonstration
Vaasan Kesä festival	Vaasa/Finland	June 16 to 18, 1972	DIMI-O; DIMI-S	Exhibition
Deal / Nordic Music Days	Oslo/Norway	September 3, 1972	DIMI-O; (DIMI-S)	Live performance / Exhibition
Dimensio exhibition 1972	Tampere/Finland	September 16 to October 15, 1972	DIMI-O; DIMI-S	Exhibition
Blue Danube w/ Oulu Symphony Orchestra and DIMI-O	Oulu/Finland	October 18, 1972	DIMI-O	Demonstration
Samuel Beckett play *Act without words* w/ DIMI-O and theater group Scene 7[411]	Oslo/Norway	[s.a. 1973?]	DIMI-O	Live performance

[410] See Ojanen (2017): https://doi.org/10.5281/zenodo.842854.
[411] For more about the theater group Scene 7 see: https://sceneweb.no/nb/organisation/5045/Scene_7-1966-1-1; On Riitta Vainio, Arild Boman and DIMI-O see: http://kiasma.fi/kiasma-lehti/16.php?lang=en&id=4

Event	City/Country	Date	Instrument(s)	Type of appearance
Psychological tests w/ DIMI-O	Oslo/Norway	[s.a. 1973?]	DIMI-O	Demonstration
Talviunesta herääminen / Yle Liisankatu concert	Helsinki/Finland	February 27, 1974	Sähkökvartetti	Live performance
Electronic music seminar / Dimensio exhibition 1974	Espoo/Finland	November 7 to 17, 1974	DIMI-T	Demonstration

7.2.1 Electroacoustic tape music in a concert setting

The composers' attitudes towards the electroacoustic tape music concert settings reveal fascinating aspects of the role and state of electroacoustic music in the 1960s and the 1970s. In that tape music works are realized in the studio and reproduced from the tape in concert, electroacoustic tape music in a concert setting is an extension of studio work. This does not exclude the role of an interpreter from the communication chain, however. The reproduction technology and the engineer play similar roles as the conductor and the musicians in a traditional setting (Ojanen 2015). Herein lies the interest in the electroacoustic music concert setting.

Electroacoustic music in a concert setting is closely related to the concept of *acousmatic music*, which is based on the idea of a loudspeaker orchestra. Interestingly, this was the aspect that contemporary composers criticized at the time. The fact that there was nothing visual for the audience to follow was considered a general problem in tape music concerts: the core idea of acousmatic music had turned against itself. Within the scope of this study, Lindeman's and Ruohomäki's points of view differ from those of François Bayle, who developed an acousmonium – a loudspeaker orchestra – for "pure listening" (Chadabe 1997, 68).

Even in the mid-70s Ruohomäki was criticizing the electroacoustic music concert setup in which there was nothing the audience could follow.[412] Lindeman also complained that the "traditional concert setting is too stagnant for this type of music".[413] He was referring to tape music concert settings here – not to live performances with electronic musical instruments. He disregarded the idea of live performance because he did not believe he had the necessary equipment. His main intention was to move away from the unpredictable concert performance situation, in which the composer must rely on the conductor and the orchestra as interpreters. In this sense Lindeman echoes the views of Igor Stravinsky, who anticipated music composed to be performed only through gramophones without the interpreter (see Katz 2010, 113). Unfortunate technical problems ruined the Finnish premier of his prize-winning *Ritual* in the chamber music space in Finlandia Hall on December 1, 1972.[414]

[412] Ruohomäki (1976).

[413] Lindeman (1975) in an interview with Sermilä.

[414] See the concert reviews by Seppo Heikinheimo and Petri Sariola in hitherto unidentified newspapers in Lindeman's scrapbook (Lindeman et al. 2020). Heikinheimo's review entitled *Ligetiä ja*

Even though Lindeman used the DICO in real-time improvisation in the studio environment to produce the raw material for his tape music works, he did not consider it an instrument for live performance. He only performed with it live on one occasion, on November 17, 1969. Unfortunately, no documentary evidence of this event has survived.

In Lindeman's opinion, the perfect environment for listening to electroacoustic music was at home through a hi-fi sound-reproduction system in a dedicated environment, or in an exhibition space in which the sounds could be distributed and the audience could move. He produced soundscapes for three of Ruutsalo's kinetic art exhibitions in the late 1960s and early 1970s, which provided a solid platform for Kurenniemi's instruments and electronic sounds in general. The Amos Anderson Art Museum provided the venue for the *Valo ja liike 2: International exhibition of kinetic art* from May 10 to June 8, 1969. Ruutsalo's *Kineettisiä kuvia* (Engl. Kinetic pictures) exhibition toured in eight cities in Finland in the spring of 1970. Lindeman's *Mobile* (1969) provided the electronic soundscape in both exhibitions.

7.2.2 Live performances with Kurenniemi's instruments

Kurenniemi frequently presented his instruments to the public – especially the DIMI-A and the DIMI-O. However, it was mainly to demonstrate them, and there is little surviving documentation of the live performances. This is interesting given that, in the context of computerized and automated music production, Kurenniemi's key design themes included real-time instrument control and user interaction with the instrument. In fact, live-performance potential was anticipated by users in the early design phases of many of his instruments. For example, Kurenniemi planned to add c-casette recorder as a mass storage device to the DIMI-A to facilitate live usability of the instrument.[415] This plan was never materialized, however. The live-performance feature was successful only in the Sähkökvartetti, which was explicitly designed as a performance instrument, and in the DIMI-O with its flexible optical input. One reason for the rare live performances was that the instruments were new and there was no repertoire for them in the same sense as there is a repertoire for the violin, for example. The few public performances also reflect their initial design target as studio-based instruments – and in some cases their background in the computer-metaphor-driven design process.

The Integrated Synthesizer was used mainly in the studio. Its sounds were frequently heard in exhibitions and in concerts, but they were recorded on tape and reproduced from it. A few surviving documents shed light on its use

oppilaita (Engl. Ligeti and his students) was most likely published in *Helsingin Sanomat*. The title of Petri Sariola's review is *Modernismin arkipäivää* (Engl. The everyday life of Modernism).

[415] Kurenniemi (1971a, 40)

outside the studio environment, however, even though only in two events.[416] Its first documented appearance was in the algorithmic music seminar on July 7, 1965 that was part of Jyväskylän Kesä, in which it was used for demonstration purposes. No audio or visual recordings of the event have survived, therefore further analysis is impossible.

Kurenniemi performed twice with the instrument on February 9, 1968, in the *Sähköshokki-ilta* (Engl. Electroshock Evening) event that was part of Eino Ruutsalo's *Valo ja liike* exhibition at the Amos Anderson Art Museum in Helsinki. The only surviving audio document related to the event is a sound recording of rehearsals on February 8, the day before the concert. The recording is not an intentional document, however, although it has significant documentary value. It is a tape from the recorder used as a delay for the machine poems, a dual mono recording in which delayed signals ping-pong from one channel to another. Ruutsalo used a monophonic version of the tape later as a soundtrack in his film *Runoja 60-luvulta* (Engl. Poems from the '60s; 1987; see Home 2013, 20–22). The tape, which Ruohomäki fortunately digitized in the 1990s, has been lost. The digitized version was released by Ektro records in August 2013, and a digital copy of the original tape is archived in Music Finland.[417]

Contemporary newspaper announcements and reviews of Sähköshokki-ilta report that Kurenniemi modulated music and speech during the improvised session.[418] However, according to the sound recording of the rehearsals the speech was modulated only with the tape delay and not with the Integrated Synthesizer, which produced synthesized musical responses to the recitation but did not modulate the speech (see Figure 110). The Integrated Synthesizer included distortion processing for external signals, but this could not be used at the same time as being used as a performance instrument. It is impossible to ascertain after 50 years whether a stereo configuration was used to form a spatial effect in the exhibition space. Judging from the photographs, a complex loudspeaker arrangement was not set up in the exhibition space (see Figures 111 and 112). Apart from the distinctive Vox speaker grill (probably a Vox PA system or the guitar amplifier used by Donner in his *Execethis*), no speakers are visible in the photographs. Given Ruutsalo's declaration about the exhibition, the fact that *Saharan Uni* was the first stereophonic electroacoustic work in Finland, and the earlier radical experiments with spatial sound conducted by Donner, who was the musical conductor of the evening, the sound-diffusion experiments would have been more than obvious.

[416] At the time of writing this text, there was a note in a retrospective interview by Nilsson (2019) that he used an early version of the Integrated Synthesizer in the Art Parlour Samlaren in Stockholm in the fall of 1964, but no contemporary documentary evidence has been found yet.
[417] An excerpt of this early Finnish machine poetry with electronic improvisation can be heard on Ektro records' SoundCloud page.
[418] See e.g. *HS* (1968, 17 / January 17, 1968).

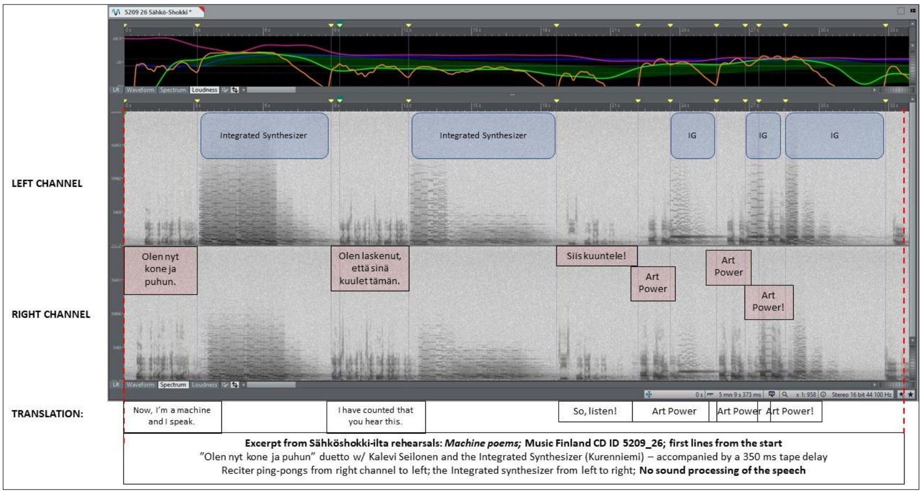

Figure 110. Call and response patterns in the machine-poem improvisations. The Integrated Synthesizer was used merely as a sound source not as a sound-processing unit for the recited poems – only the 350-ms tape delay was used for processing both the speech and the Integrated Synthesizer. In the ping-pong delay configuration, the Integrated Synthesizer's dry signal appears first on the left channel and the 350-ms delayed signal on the right channel – the reciter appears first on the right channel and the delayed signal on the left channel. (image: Ojanen 2019)

Figure 111. Sähkö-shokki-ilta (Electric Shock Evening) at the Amos Anderson Art Museum on February 9, 1968: an improvisation with the Integrated Synthesizer and electronic zither; Henrik Otto Donner with the microphone, Philip Donner and Mattijuhani Koponen with the electronic zither, in other words a zither with guitar microphones (photo: unknown / The Amos Anderson Art Museum)

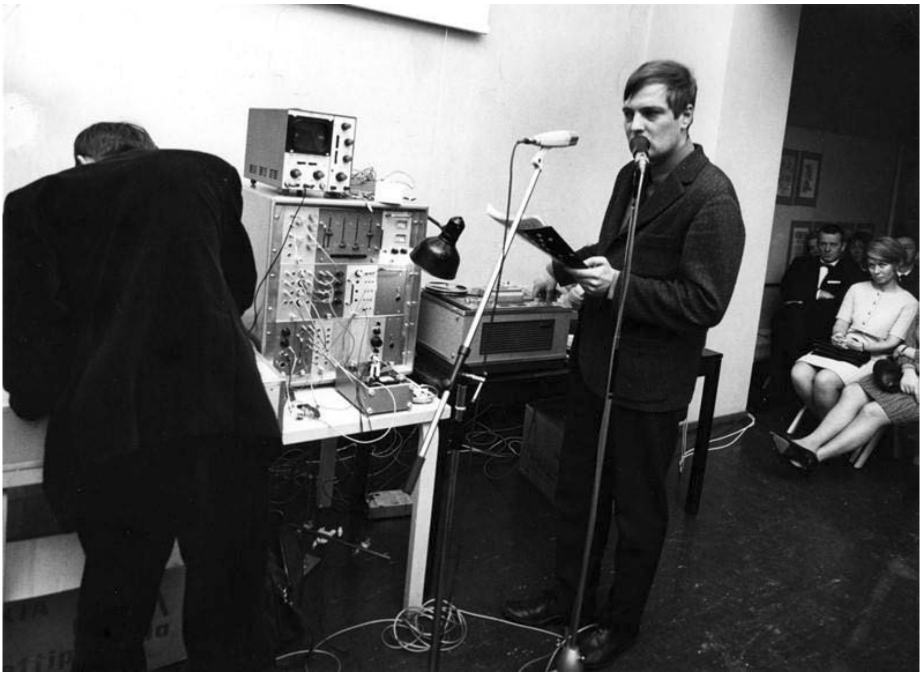

Figure 112. Sähkö-shokki-ilta (Electric Shock Evening) at the Amos Anderson Art Museum on February 9, 1968: the machine poems; Erkki Kurenniemi (left; back to the camera) operating the Integrated Synthesizer tone generator and Claes Andersson (right) reading poems at the microphone processed with the tape delay. Between Kurenniemi and Andersson is the rack of unidentified studio equipment from the University Studio. The same equipment rack appears in the photo with Numminen and the almost-finished Sähkökvartetti (see Figure 24). (photo: unknown / The Amos Anderson Art Museum)

The Sähkökvartetti (instrument) was used in several live performances by Sähkökvartetti (the band), but only three recordings have survived. One could conclude from the recordings and Numminen's description that there was a loose plan for the performance, but its realization was adjusted freely from one event to another. Common features in the versions of *Kaukana väijyy ystäviä* (1968) included Numminen's introduction in which he presented the title or the line-up of the group, as well as the main theme of *Kaukana väijyy ystäviä*, which he sang in Finnish and Swedish – on some occasions also in English and German. Arto Koskinen, who composed the main theme, accompanied Numminen with the melody machine. Otherwise, the performance consisted of collective improvisations and a drum solo "if there was enough time to perform it".[419]

The three surviving audio documents do not indicate any kind of strict formal structure, which was followed in performances of *Kaukana väijyy ystäviä*. The version of November 25, 1968 in the *Kommunikaatiokonsertti* (Engl. Communication concert) in the University of Helsinki Great Hall, for

[419] Numminen (2018) in an interview with Ojanen.

example, starts with the main theme of the work (see Figure 113), whereas in *Sähköinen tapahtuma Vanhalla* on November 17, 1970 it appears in the middle of the performance with the melody machine, and again at the end of the performance sung by Numminen in Finnish and Swedish (see Figure 114). In a short excerpt from its performance in the documentary *Ungdom, för helvete!* (Engl. Youth, bloody hell!), directed for television by Anki Lindquist, Sähkökvartetti performs as a trio while Numminen's singing and the theme are not heard at all. The length of the *Kaukana väijyy ystäviä* performance varied from a few minutes to one-and-a-half hours. The longest performance took place in the Amos Anderson Art Museum on September 29, 1968.

The output of the instrument was typically processed only with a spring reverb. The unit – the Telefunken spring reverb – is visible in the documentary *Ungdom, för helvete!*. The output was processed with a tape delay in *Sähköinen tapahtuma Vanhalla*[420]. Ruohomäki recalls that he hastily picked up a tape recorder for the band from the University Studio, and the setup did not turn out to be what he had expected.[421] The tape delay appears suddenly in the middle of the performance and remains present until the end. The tape speed is varied twice, first when the speech is adjusted from the faster to the slower mode (apparently 15 inches/second to 7.5 inches/second), and then again back from the slower to the faster mode.

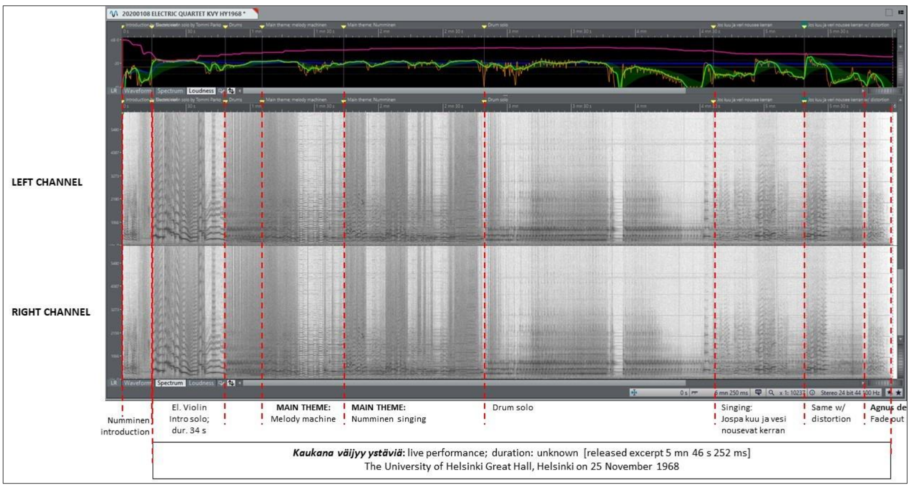

Figure 113. The Sähkökvartetti performance of *Kaukana väijyy ystäviä* on November 25, 1968 (image: Ojanen 2020)

[420] In the surviving documentary recording Kurenniemi describes the event as Elektrononstop.
[421] Ruohomäki (2018) in an interview with Ojanen.

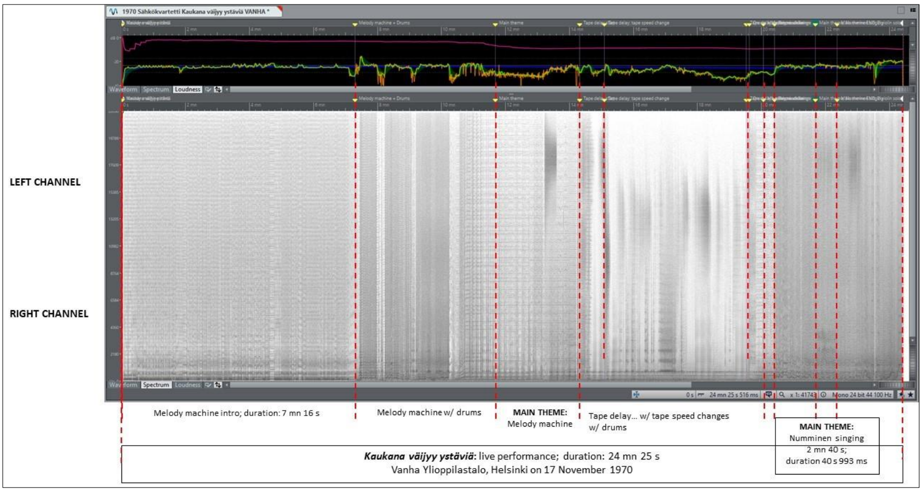

Figure 114. The Sähkökvartetti performance of *Kaukana väijyy ystäviä* on November 17, 1970 – presumably their last performance (image: Ojanen 2020)

Two documented events and their comparison provide an interesting point of departure for analysing the playability and live performance potential of Kurenniemi's designs. The first event was an improvisation by Ruohomäki (DIMI-A), Ilpo Mansnerus (flute), Ralf Gothoni (piano) and Teppo Hauta-aho (bass) in *Sähköinen tapahtuma Vanhalla* on November 17, 1970, and the second was Ruohomäki's *Talviunesta herääminen* (1974; Engl. Waking up from hibernation) by Olli Ahvenlahti (the Minimoog), Mircea Stan (trombone) and Kurenniemi (the VCS 3 and the Sähkökvartetti together with Ruohomäki) on February 27, 1974. The three photographs of the setup used in *Talviunesta herääminen* that have survived, in addition to the audio document, reveal details of the instruments and technology used in the performance (see Figures 117, 118 and 119).

The points of departure for these improvisations were different. The musicians in the DIMI-A improvisation, Gothoni, Mansnerus and Hauta-aho, are clearly anticipating a response from the machine, whereas in *Talviunesta herääminen* Stan and Ahvenlahti are playing around on top of the static pulse produced by the Sähkökvartetti sequencer. The background of the musicians also plays a role here. Those who were classically trained anticipated the responses and reactions from the DIMI-A, whereas those experienced in Jazz improvisation adjusted to static, non-responsive accompaniment.

In addition, Ruohomäki – having more experience in 1974 – changed the premises for *Talviunesta herääminen* from those in the DIMI-A improvisation three years earlier. In 1970, he programmed a few sound gestures and pre-arranged musical segments in the DIMI-A, which he could choose during the improvisation, whereas in 1974 the improvisation was built upon the static tempo dictated by Sähkökvartetti – and here it resembles the point of departure for the radio play *Vihreä eläin*. Moreover, *Talviunesta herääminen* is more clearly structured in sections, each with a unique content and purpose, than the 1970 improvisation (see Figures 115 and 116). The initial intention behind the work is clearer than in 1970 when the musicians improvised while they were waiting to see if anything came out of the DIMI-A to which they could respond.

The improvisations also reveal the differences in the user interfaces and the usability of the instruments. The readability of the Putney and Sähkökvartetti user interfaces is superior, and their real-time controllability is more flexible than in the DIMI-A user interface, in which the functional status is hidden and has to be verified by listening. DIMI-A's memory constraints restrict the number of possible pre-programmed musical gestures, and rapid change is impossible. Donner's and Kurenniemi's anticipatory introduction in 1970 is also noteworthy. Even before the performance, they saw the improvisation as a test and emphasized what was not going to happen rather than how the group could succeed in performing with the new instrument.[422]

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[422] Donner: "Seuraavaksi saamme sitten kuulla ja nähdä, miten DIMI-musiikkikoneen kanssa improvisoi kolmen hengen muusikkoryhmä, johon kuuluvat Teppo Hauta-aho, basso, Ilpo Mansnerus, huilu, ja Ralf Gothoni, piano. Ja ennen kuin soittajat pääsevät alkuun, niin DIMIn suunnittelija Erkki Kurenniemi ja minä yritämme hieman selvittää, mistä tässä kokeessa on kysymys. - - - Niin siis ehkä tärkeämpää kuin selvittää se, mitä kohta saattaa tapahtua, on selvittää se, mitä ei tule tapahtumaan. Toisin sanoen tämä musiikkikone ei pysty muuntamaan näiden soittimien tarjoamaa materiaalin muuta kuin sointivärin suhteen – eikö niin?"; Kurenniemi: "Joo - - - tai ehkä on parempi sanoa, että tällä hetkellä DIMI pystyy ainoastaan tuhoamaan sävelen ja sikäli kuin se ei täysin pysty tuhoamaan sitä, niin siinä on asian mahdollinen kiinnostavuus." Donner: "Tämän lisäksi DIMI pystyy, kuten jo aikaisemmin konsertin aikana on esitelty, - - - itse tuottamaan musiikkistuktuureja, joihin muusikot sitten erilaisin keinoin voivat reagoida ja vastata." Kurenniemi: "Nyt konepuoli ja musiikkipuoli alkoivat neuvottelut keskenään siitä, mitä tässä improvisaatiossa on tarkoitus tehdä - - - ja on sanottava, että tää on siinä mielessä vielä kokeilu, että konepuolella - - - tarvitaan vielä soittaja. Mukana ehkä jo seuraavassa Elektrononstopissa voidaan kokeilla tilannetta, jossa samalla lailla kylmiltään muusikot joutuvat vastatusten tietokoneen kanssa, joka toimii täysin omillaan ilman operatöörin apua. Konsertti-instrumenttina DIMIä rajoittaa tällä hetkellä erityisesti muistin pieni koko. Tuossa Juuso on ohjelmoinut laitetta - - - tallettanut muistiin sata erilaista käskyä suunnilleen, joka on nyt maksimimäärä." Donner: "Eikö muistia voida helposti lähiaikoina laajentaa?" Kurenniemi: "Kehityksen vauhti on niin ilahduttava, että jos nyt – tämä DIMIhän rakennettiin viime kesänä – ja jos nyt vaihdetaan muisti viisi tai kymmenen kertaa suuremmaksi niin sen hinta on pikkusta hiukan halvempi kuin tämä vanha sadan sanan muisti." Donner: "Joo, ja toivokaamme, että tämä neuvottelu koht'puolin johtaa tuloksiin ja saamme todella kuulla jotain."
(Engl. Donner: "Next we can hear and see how the group of three musicians consisting of Teppo Hauta-aho, bass, Ilpo Mansnerus, flute, and Ralf Gothoni, piano improvise with the DIMI music machine. And before the musicians get started the designer of the DIMI Erkki Kurenniemi and I try to explain what this test is about. - - - So perhaps more important than figuring out what might soon happen is to explain what is not going to happen. In other words, this music machine cannot modify the material provided by these musical instruments except the color of the sound – isn't that right?" Kurenniemi: "Yeah… or maybe it is better to say that at present the DIMI is only capable of destroying the notes and, as far as it is not completely capable of destroying it, there is potential interesting side of it." Donner: "In addition to this, the DIMI is capable, as has been demonstrated earlier during the concert, of producing music structures on its own, to which musicians can then react and respond in various ways." Kurenniemi: "Now the engineering side and the mu-

Kurenniemi also critically stated that this version of the DIMI was only able to distroy the notes performed by the other musicians and it could not respond to their playing. He thought that subsequent versions would participate in the performance. The improvisation is not nearly finished if an unknown participant asks in a disappointed tone if it is over yet, and Donner laconically states that the resulting performance was not much.[423]

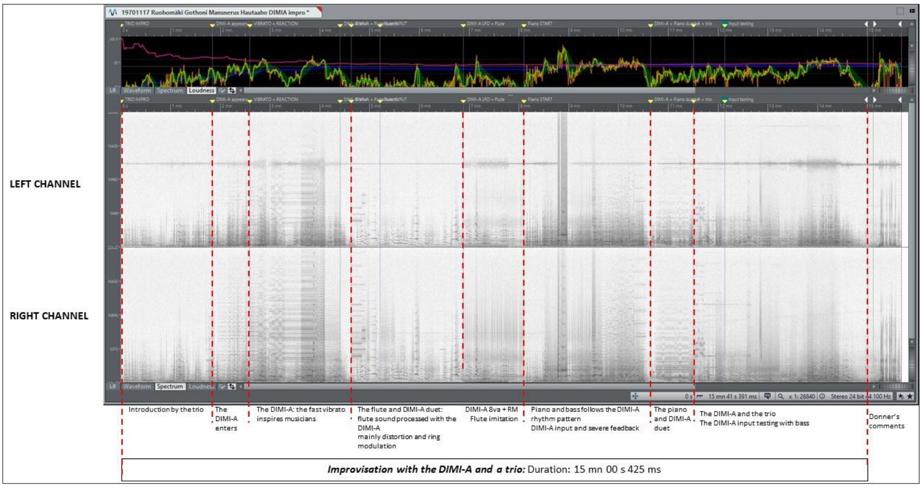


Figure 115. The DIMI-A improvisation in *Sähköinen tapahtuma Vanhalla* on November 17, 1970: the structure of the improvisation is arbitrary and driven by the free associations of the musicians and their reactions to the sound gestures performed with DIMI-A (image: Ojanen 2020)

sic side have begun to negotiate about what is meant to be done in this improvisation - - - and it has to be said that this is still an experiment in the sense that on the engineering side - - - a player is still needed. Perhaps already in the next Elektrononstop, it can be tried out a situation where musicians, similarly without any preparation, are confronted with a computer that works completely on its own without the help of an operator. As a concert instrument, the DIMI is currently limited especially by the small memory size. There, Juuso has been programming the device - - - has stored approximately a hundred different commands in its memory, which is now the maximum number." Donner: "Can't the memory be easily expanded in the near future?" Kurenniemi: "The pace of development is so gratifying that if you now – this DIMI was built last summer – and if you now change the memory to five or ten times bigger its price is a bit cheaper than this old one-hundred-word memory." Donner: "Yeah, and let's hope this negotiation will soon lead to results and we will really hear something.")

423 Unknown: "Olikse siinä? Eikö oikein onnistunut? Mitä me sitten tehdään? Joks tää loppu?" Donner: "Joo, siis ei tästä tän kummempaa surinaa tällä kertaa tullut ja jatkamme nauhakonserttia." (Engl. Unknown: "Was that it? It failed? It didn't really succeed, did it? What shall we do now? Is this done with now?" Donner: "Yes – so not much of a buzz this time and let's continue the tape music concert.)

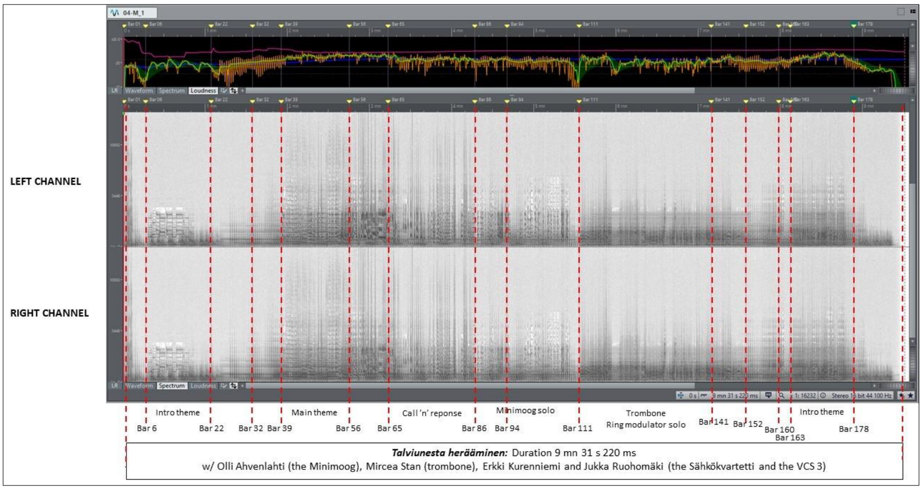
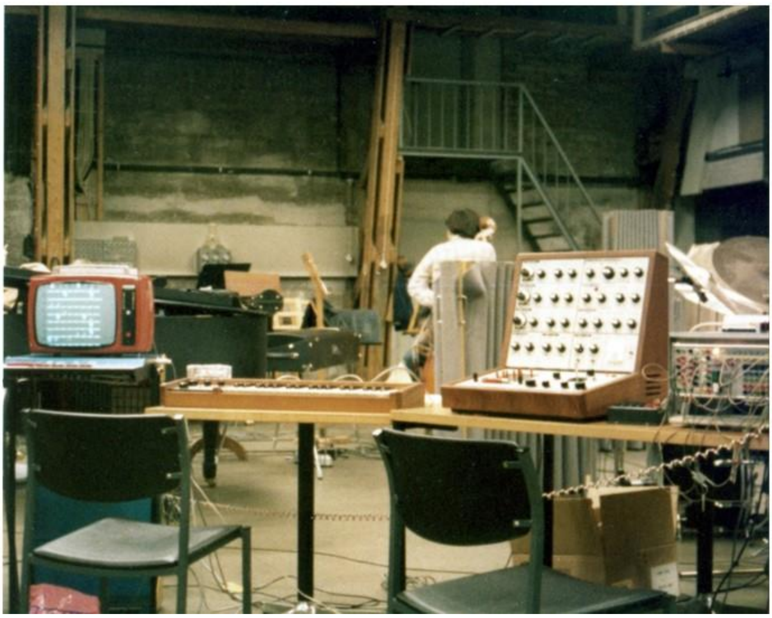


Figure 116. The structure of Ruohomäki's *Talviunesta herääminen* (1974) performed by Olli Ahvenlahti (the Minimoog), Mircea Stan (trombone), and Kurenniemi (VCS 3 and Sähkökvartetti together with Ruohomäki) on February 27, 1974 (image: Ojanen 2020)

Figure 117. See the caption on the next page.



Figures 117–119. The Sähkökvartetti, the Putney, the Dimix and other studio equipment set up for the performance of *Talviunesta herääminen* in Yle's Liisankatu Studio on February 27, 1974. In the photo on the previous page Ruohomäki is standing with his back to the camera while Olli Ahvenlahti is on the right side of the picture on the piano with the Minimoog, Mircea Stan (trombone) in front of the piano, Pentti Lahti (saxophone) and Tapani Ikonen (drums). The upper picture on this page shows the two Revox tape recorders set up for the tape delay configuration and the back panel of the Putney. The DIMIX mixing console and patch bay with its red-housed monitor on the right, the Putney and its keyboard in the middle and half of the Sähkökvartetti front panel on the right in the lower picture. (Photos: Erkki Kurenniemi / the Finnish National Gallery / Erkki Kurenniemi archive.)

7.2.3 Instrument tests and demonstrations

Tests and demonstrations of Kurenniemi's instruments in front of the general public were noted and well received by the media. Reviews of demonstrations at various events acknowledge the prototype state of the instruments, and refer to the enthusiasm and excitement about Kurenniemi's forthcoming designs. Heikinheimo does not mention the Integrated Synthesizer in his review of Jyväskylän Kesä,[424] but the instrument is highly visible in the accompanying photograph (see Figure 14 in Chapter 5.1 3). During the seminar the public could test the instrument after Kurenniemi had set it up, thus the event was a demonstration rather than a live performance. The photograph depicts an enthusiastic audience – including Swedish composers Ralph Lundsten and Leo Nilsson – fascinated with the Integrated Synthesizer, referred to in the caption as *musiikkitietokone* (Engl. music computer; see Figure 14). The seminar comprised presentations by Kurenniemi ("About definitions, programs, machines and all that"), Carl Lesche (on the esthetics of computer music) and Knut Wiggen ("Kompositionssystemet Wiggen 1"; Engl. The Wiggen 1 composition system).

Other significant demonstrations, which also promoted electric sounds and Kurenniemi's instruments to contemporary society, took place at festivals and seminars, and in concert settings representing both experimental and classical music. There were notable demonstrations of the DIMI-A and the DIMI-O with public-outreach potential. Having completed the DIMI-A, Kurenniemi frequently presented it, but he set it aside soon after the first DIMI-O prototype was ready to be demonstrated. The typical demonstration setup with the DIMI-A was similar to that at the *Sähköinen tapahtuma Vanhalla* event. There was an improvisation session featuring a classically trained musician, and both Kurenniemi and Ruohomäki demonstrated the instrument. Kurenniemi described its key features, while Ruohomäki presented them by programming simple and known tunes such as the traditional Swedish song *Gubben Noak*.

The flexible user interface of the DIMI-O facilitated the demonstration of the DIMIs. In his DIMI-O demonstrations Kurenniemi even asked the audience to participate in the sessions. He did this in the seminars and festival presentation of the art group Elonkorjaajat, first during the Intermedia event at Vanha Ylioppilastalo in Helsinki on May 26, 1972, and then during the Vaasan kesä festival in June 1972. Two demonstration events with the DIMI-O that are of particular interest were the session at Yle on September 22, 1971 and the one with the Oulu Symphony orchestra on October 18, 1972. Its suitability was also tested in various Norwegian contexts, such as experimental theater and psychological testing (see also Chapter 5.3).

[424] Heikinheimo (1965, 11).

7.2.4 Collective performances with Kurenniemi's instruments

One of the key features of Kurenniemi's instruments relates to collective performance and music production. As with most of his designs, his visions were far-reaching and were realized only partially in his instruments. Thus, any interpretation of the use cases needs to be contextualized. Collective music making as a utopian lies behind Kurenniemi's plans to build a network for music production. He presented his ideas about terminal computers and networks for music making at the electroacoustic music conference organized in Florence in June 1968 (see also Chapter 5.1.3). For this purpose, he was also designing analog-to-digital and digital-to-analog converters. One early application of the A/D converter was in the input of the DIMI-A. Even though networked music making never happened, the idea manifested in his later designs.

On the concrete level, the Sähkökvartetti fulfils the idea of a collective performance instrument par excellence. The initial idea was to replace conventional rock group instruments with one collective instrument. Although the instrument was designed for collective performance, the intermodulation between the instruments is mainly filtering and ring modulation.[425] The light sensors in the melody machine and the light sword affect the dynamics and frequency response of the sound produced by the other players. The output of the instrument sums the signal together. Even though singing and different sound gestures of the melody machines and the drums can be identified, the output signal is glued together by the filtering and dynamic variation.

Kurenniemi and Ruohomäki tested collective performance with the DIMI-A in the studio environment in 1970, but failed to produce a consistent collective playing experience and the instrument was never used in collective live performance (see Figure 40). A situation in which each player holds their own stylus and controls each side of the plates leads to randomized performance. The fact that touching a plate on the left-hand side changes the parameter on which the selection of the right-hand side affects the performing method leads to a somewhat chaotic outcome from the players' point of view.

Collectiveness is also apparent in the DIMI-O. However, the documentary evidence typically hides the actions of the operator and the outcome is only perceived and analyzed as interaction between the instrument and the visual material presented to the camera – such as the dance movements of Riitta Vainio in *DIMI ballet*[426]. Niemelä (2019, 109–110), for example, sees *DIMI ballet* as a duet featuring Vainio and the DIMI-O, whereas the DIMI-O operator (presumably Kurenniemi) plays a significant part in the performance, which in fact is a trio. Hiding the DIMI-O operator in the original document is in line with Kurenniemi's design goal. Even though his utopian vision was

[425] Personal communication with Jari Suominen in 2020 during his latest project aimed at restoring the instrument.
[426] See DIMI ballet in: https://youtu.be/d-yHULQ2V5c

not realized in the DIMI-O, he pursued his quest to develop an instrument that could take part in the performance and genuinely react to the musical gestures of the other participants.[427]

Kurenniemi presented his DIMI music machine (presumably the DIMI-O) at the Pori Jazz festival in the summer of 1971. According to *Helsingin Sanomat*, his daily presentations tended to be collective improvisations. A similar event is reported in documentary evidence from the following summer when Kurenniemi was presenting his DIMIs (the DIMI-O and the DIMI-S) at the Vaasan Kesä festival from June 16 to 18, 1972. No audio or video recordings have survived, but Kurenniemi describes the collective improvisation in issue 18/1972 of *Tekniikan Maailma* magazine.[428] Later, he recalled the event in the DIMI Family lecture at the UNESCO Computer Music seminar held in Helsinki on August 21, 1978.[429] His interest in sex is equally present in these descriptions as performing with the instruments. Kurenniemi recalls how the participants in a collective improvisation, who were randomly chosen from the audience and thus complete strangers to each other, sat back-to-back in a circle on four chairs with the DIMI-S handcuffs around their wrists, touching each other behind their backs. Accompanying the DIMI-S sounds was the DIMI-O, its camera focused on the collective of performers.

Collective performance was the key feature of the DIMI-S. Kurenniemi even suggested that sexual union between the players was more important than the sounds of the instrument.[430] It was rarely used publicly – not at least following the initial design idea– but only privately and for fun. In public it was used mainly for demonstration purposes (see Figure 120) – alongside casual Pripps brewery visitors, who were able to play with the instrument in the brewery in which the other copy was installed.

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[427] See Kurenniemi's verbal description in *Sähköinen tapahtuma Vanhalla* presented in the previous footnote 422.
[428] See Alanko (1972).
[429] See the DIMI Family lecture audio recording in the UHMRL archive.
[430] See Pitkänen (1972, 7).

Figure 120. The DIMI-S (Sexophone) presented by Ralph Lundsten in a Swedish Television documentary (photo: unknown / Ralph Lundsten archive[431])

431 Photo available via Andromeda website: https://www.andromeda.se/wp-content/uploads/2012/10/dimi-s.jpg

8 DISCUSSION

In this chapter, I review the analytical part of the study (Chapters 5, 6 and 7) with reference to the key background concepts (Chapters 2 and 3), and contextualize the situation in Finland with reference to the global development of electroacoustic music (Chapter 4). As I note in the Introduction, I emphasize the need for both description (basic research) and analysis (interpretation) of the research subject.

8.1 Kurenniemi as an instrument designer and an artist

The distinctive feature in Kurenniemi's work is his double role in the field of electronic music. On the one hand, he was an *engineer* and *an instrument designer*, and on the other he was an *artist* in his own right. At the time, these roles formed a unique combination on the Finnish scene, which was characteristic of Kurenniemi but not of his (Finnish) contemporaries.[432] Otto Donner and Erkki Salmenhaara emphasized their artistic roles whereas Hannu Viitasalo and Jouko Kottila had expertise in the worlds of engineering and business, respectively. M.A. Numminen, Ralph Lundsten, Leo Nilsson and Osmo Lindeman had a background in electronics, and therefore an understanding of both engineering and art. However, Kurenniemi was the one who could cross the boundary between the two worlds. Resembling Robert Moog, he was a *boundary shifter*.

According to Pinch and Trocco, Moog had an "ability to move between the worlds of engineering and music and bring about a transformation" (Pinch & Trocco 2002a, 313–14; Pinch 2009, 190). Kurenniemi failed to move into the fields of politics and economics, and in this sense he was not a *heterogeneous engineer*: this is something that, according to John Law, is required of a successful entrepreneur (see Law 2012).

Experimental practices melded art and technology in Kurenniemi's work and produced a new form of inter- and multimedia aesthetics that was "totally future-oriented" (Ballantine 1977, 241). Not only did he transverse the worlds of art and technology, he moved agilely between his own time and his utopian dreams of the future. This emerges as a contrast between his futuristic envisioning presented in contemporary magazine articles, and his descriptions of viable technical solutions in official documents such as business pro-

[432] Viitasalo (2015) in an interview with Ojanen & Suominen.

posals for DEF's customers. Kurenniemi was both a user and a designer of technology. As a user he employed existing electronic components and textbook examples, whereas as a designer he developed and experimented with new technological artifacts. In the latter respect, his consumption of technology exemplifies the DIY and modification culture. He modified existing technology to match his visions, which he eventually could not realize.

The underpinnings of Kurenniemi's work lie in his two roles as engineer and artist, even though on a personal level these roles were intertwined.[433] As revealed in his diaries, his train of thought switched seamlessly from one topic to another. The resemblance to Thomas Edison's notebooks as Hughes (1986, 285) describes them is evident. The only difference is that whereas Edison's thoughts were entwined with economics, technology, and science, Kurenniemi's visions encompassed future technologies such as computers, artificial intelligence, electronic devices and their music technological applications. He mixed this with girlfriends, sex, pornography, and narcotics – even on the most concrete material level of taping pubic hair on his diary pages beside the technical drawings (see Paasonen 2013, 55), and seamlessly overlaying the technological artifact on a woman's body on the enigmatic poster and the record sleeve used for marketing the DIMI-A (see Figures 121).

As described, from the *engineering perspective* Kurenniemi's designs were based on programmability and algorithmic composition, in other words the computer metaphor. He envisioned a musical instrument as an automated music-making machine that would replace the burdensome tape-editing process, which Donald Buchla called tape buffering.[434] A similar trend, which eventually led to the development of musical sequencers, emerged globally at the same time, implemented in Donald Buchla's synthesizers, for example, and a few years later by Robert Moog in his synthesizers. On the practical level, a version of this vision emerged in one form or another in all Kurenniemi's instruments. The computer metaphor – inspired by his early programming experiences with the analogue computer at the Department of Nuclear Physics – was emphasized even further when he chose to employ digital logic rather than voltage-controlled technology in sound synthesis, and in the sequencer and memory applications of his instruments.

[433] See Pitkänen (1972, 7).
[434] Buchla Associates (1966, [3]).

Figure 121. The *Dimi is born* poster with flying cows and the DIMI-A user interface laid on top of a woman's body was also used as on the record cover: it was designed by Meri Vennamo, who was Kurenniemi's wife[435] at the time. (photo: Meri Vennamo and Musica)

435 See the announcement of Vennamo and Kurenniemi's marriage in *Helsingin Sanomat* on May 15, 1970 (HS 1970, 13): they were married the day before, on May 14, 1970.

Kurenniemi experimented with various instrument-control methods in his user interface design, and only one of his instruments included a piano-style keyboard. It is worth noting here that when he made his early designs the synthesizer was not (generally) considered a keyboard instrument, and only slowly came to be seen as such. In this respect, the 1960s was a time of interpretative flexibility (Pinch & Trocco 2002b, 67–68). Moog integrated the first piano-style keyboard into his modular system in 1965. Buchla, on the other hand, never used a piano-style keyboard – a feature of his design that was highly valued by electronic music composer and musician Suzanne Ciani, for example: in her view the modular synthesizer was taken over by tonal music when a keyboard was added to the instrument.[436] It is notable that even though he did not include such keyboards in his instruments, Kurenniemi was constrained by tonal music due to his engagement in note-based programmability.

One version of Kurenniemi's future vision emerges if his separate instrument-design plans are seen as one continuous development project. Even though his individual instruments remained prototypes, his studio-design principle repeatedly reflected them. They could produce automated musical sequences in real time. Contemporary newspaper and magazine articles frequently referred to the first DIMI as a musical computer.[437] However, in an article published in Apu magazine in 1971, Kurenniemi cautions against likening the DIMI-A to a computer because the instrument is not capable of making decisions and associations.[438] Later in 1971, in an article published in the musicological journal Musiikki, he presented his most far-reaching vision of his studio: "in the 1980s a composer will communicate with his studio unless the instruments are capable of reading his or her thoughts directly".[439] Here, he was envisioning something that is understood nowadays as artificial intelligence. It is therefore understandable that he was not satisfied with the contemporary state of technology.

It is noteworthy that Kurenniemi was envisioning completely novel instruments rather than concentrating on further developing or enhancing existing musical tools. This placed him in a situation in which there was no repertoire for his instruments in the traditional sense. Composers realized works *with the instruments* rather than composing *for the instruments* – which was typically the case with concertos written for piano, violin, flute, and so on. There are a few exceptions, however. Osmo Lindeman concentrated solely on the DICO in his early electronic works. However, he soon rejected his DICO-based works because he thought that he had accepted them too easily when he composed them.[440] Other exceptions include the Sähkökvartetti (the

[436] For the Ciani interview see Fantinatto (2017). See also Ciani (2016).
[437] *HS* (January 21, 1971, 5); *HS* (January 21, 1971, 13); Leino (1971, 35).
[438] Leino (1971, 35).
[439] Kurenniemi (1971a, 41); see also Kurenniemi (2015, 255–260).
[440] Lindeman (1975) in an interview with Sermilä.

instrument) and the Andromatic. However, after their initial appearances as special-purpose instruments[441] both were used as general-purpose sound sources in the studio environment.

Similar exceptions from the DIMI synthesizer series include the works *for the* DIMI-A on the promotional sound recording *Dimi is born* (1970) and Kurenniemi's *Deal* (1971/72) for a DIMI-O-like instrument configuration. Ruohomäki's *Mikä aika on* could be considered a composition for the DIMI-A. The Bach arrangements, on the other hand, were realized with the instrument. Kurenniemi describes the technical setup required to implement the work in the score of Deal, but he does not refer to the DIMI-O per se, rather to any similar setup, despite the fact that the work was inspired by the newly finished DIMI-O.

On the *artistic level*, the ideas guiding Kurenniemi's work reflect many contemporary international trends. Even though he did not form any systematic tenet for his artistic activity, he repeatedly referred to a few ideas and principles related to art and technology in various interviews and writings throughout the 1960s and 1970s.

In 1967, he envisioned the future digital composer as a trendsetter or industrial designer rather than a traditional composer laying out a prescribed score for a musical work based on his or her initial ideas (mental schema). According to Kurenniemi, the digital composer of the future would concentrate on algorithms and production technology rather than sonic outcomes.[442] In this sense he was anticipating not only the mass reproduction of musical products such as sound recordings, but also the automated mass and on-demand production of new music whenever needed. The process originates from the computer metaphor – a machine capable of executing tasks according to a pre-programmed script.

It was Kurenniemi's view that music would eventually lose its identity, and that the digital music of the future would at least be cheap, if nothing else.[443] I read this as referring to the disappearance of the composer as an individual author, which could also even obviate copyrights and royalties (in other words, music will be cheap). This utopian vision resonates perfectly with contemporary performance and conceptual art ideology, which "insisted - - - on an art that could not be bought and sold" (Goldberg 2001[1979], 7). Kurenniemi was not intent on dismissing the composer altogether, however, given his DIMI-T experiments and his aim to design mind-reading studio equipment. He wished to expand the means of music production and bypass the intermediate technology such that composers could directly communicate their vision to an output device.

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[441] The Sähkökvartetti (the instrument) for Sähkökvartetti (the band) with M.A. Numminen mainly playing a dedicated work *Kaukana väijyy ystäviä*, and the Andromatic as a case-specific sound installation as a part of the *Feel it* exhibition.

[442] Kurenniemi (1967) in an interview with Oura.

[443] Kurenniemi (1967) in an interview with Oura.

Composer Jukka Ruohomäki wrote down Kurenniemi's rules at the turn of the 1970s: 1) a work must be completed in a single day and 2) consecutive sounds must be chosen so that they are totally inconsistent or surprising and have no rational relationship with each other (see Ruohomäki 2020, EH22). The first rule in particular reflects an essential aspect of Kurenniemi's attitude towards artistic work (Ruohomäki 2020, EH34/10–11). In addition to his rules, there were recurring themes in his writing such as: only by abusing technology can we control it,[444] and eventually electronic technology will amalgamate all art forms – music will be experienced as pictures or even as material artifacts such as sculptures.[445]

[444] See Taanila (2002).

[445] See Kurenniemi (1971b, 38): "Kertakäyttötaide. Teokset katoavat kosketeltavasta maailmasta koska ne ovat enimmän aikaa tarpeettomia. Kuvan ei tarvitse roikkua seinällä muulloin, kun joku katsoo sitä. Ei silloinkaan, jos seinä on maalattu ajattelevalla maalilla. Kun teos on lausuttu ohjelmointikielellä, se voi realisoitua milloin ja missä tahansa, missä vain on tulostusväline. Tai muoto realisoidaan aivoelektrodien välityksellä suoraan tajuntaan. (Ensi keväänä pidetään jossakin kongressi jonka teemana on näön palauttaminen sokeille videokameran ja aivoelektrodien avulla.) Tai heittää laserilla aurinkoon, sehän voi olla elävä. Teos voidaan säilyttää reikäkorteilla, reikänauhalla, magneettikortilla, ferriittirenkaissa, magneettinauhalla, MOS-transistoreissa, levymuistissa, hologrammissa, magneettikuplina tai paperille kirjoitettuna. Se voidaan tulostaa musiikkina digitaalisyntensaattorilla, tekstinä rivikirjoittimella, grafiikkana plotterilla, filmille COM-(Computer-Output Microfilm)-laitteella, TV-ruudulle, kuvanauhalle, metalliin, puuhun tai muoviin tietokoneen ohjaamalla työstökoneella, latoa tietokoneohjatulla latomakoneella ja se voidaan hävittää yhdellä DELETE FILE käskyllä." (Engl. "Disposable Art. The works disappear from the tangible world because they are unnecessary most of the time. The picture needs to be hanging on the wall only when someone is looking at it. Not even then, if the wall is painted with thinking paint. Once a work is produced with a programming language, it can be realized anytime and anywhere, where there is a printer. Or the form is realized through the brain electrodes directly into the consciousness. (Next spring there will be a congress about restoring vision to the blind with a video camera and brain electrodes.) Or thrown with a laser into the sun, it can be alive. The work can be stored on punch cards, punch tape, magnetic card, ferrite rings, magnetic tape, MOS transistors, disk memory, holograms, magnetic bubbles, or written on paper. It can be printed as music for a digital synthesizer, text on a line printer, a graphic plotter, film on a COM (Computer-Output Microfilm), on TV screen, videotape, metal, wood or plastic on a computer-controlled machine tool, typed on a computer-controlled typewriter and destroyed with a single DELETE FILE command.").
See also Hämäläinen (1972, 36) and Kurenniemi (1969 in the documentary film *Ihmisen uudet mahdollisuudet* (Engl. The new possibilities of man). Document in Yle's archive; Media ID: MEDIA_2014_00772238; Program ID: PROG_2009_00121250; First aired on March 27, 1969. Director: Aki Oura.):"Siinä tapauksessa, että rajoitutaan tietokoneen hyvin yksinkertaiseen, alkeelliseen käyttöön toisin sanoen ei kiinnitetä huomiota sen potentiaalisiin mahdollisuuksiin todella luoda jotain uutta --- korvata säveltäjä --- jos sen sijaan tarkastellaan vain sen käyttöä musiikillisen informaation tallettajana ja käsittelijänä, jo sellasena nähdäkseni se voi aikaan saada musiikin kentässä aivan ratkaisevia muutoksia. Lähinnä ehkä vertaisin sitä tässä asemassa nuottikirjoitukseen, jonka syntyminen aikanaan saattoi säveltäjän aivan uuteen asemaan. Hän saattoi näköaistiaan käyttäen hahmottaa sellasia asioita, jotka aikaisemmin olivat vain korvan hahmotettavissa. Jos tietokoneen sisäinen kieli, koodi ymmärretään eräänlaiseksi uudeksi nuottikirjoitukseksi, se tarjoaa musiikkiväelle suunnattomasti vielä uusia tapoja hahmottaa musiikkia siitä syystä, että koneeseen talletettu musiikkikokonaisuus ei ole rajoitettu minkään aistin alueelle. Paitsi ääninä se voidaan toistaa koneesta kuvina, liikkeinä, muotoina, väreinä vaikkapa haju---." (Engl. If limited to very simple, rudimentary use of the computer, in other words, no attention is paid to its potential to create something new --- to replace the composer --- if, instead, one looks only at its use as a repository and processor of musical information, even as such I see it can bring about quite decisive

Kurenniemi's relationship with the sound quality and sonic output of his instruments was controversial and reveals interesting details about his idea of abusing technology. As he recalled in 1993, his first standalone tape music work *On-Off* was a rebellion against the clean, clear and ethereal sound ideal of the Cologne studio and Stockhausen's compositions. He thought that this rebellion might have arisen due to frustration about the poor quality of the equipment at the University Studio at the time.[446] Earlier, in November 1970, he described the fast development of the integrated circuits used in the DIMI-A memory application, noting only six months after the completion of the instrument that the technology was already many times faster, smaller and cheaper.[447] He further commented in 1978 that the 8-bit Intel microchip was not fast enough to process musical data.[448] (see also Ruohomäki 2020, EH22/5)

It is clear from these statements that Kurenniemi considered issues related to sound quality at least to some extent, and that against his tenet according to which man can rule technology only by misusing it, he pursued the sound ideal after all. In this respect, interestingly, he failed in the end to misuse his own technology for artistic purposes: for example, the initial computer-metaphor-driven design principle directed his use of the DIMI-A. In focusing on HiFi sound production and processing equipment, Kurenniemi broke away from Cascone's (2000) failure aesthetics

8.2 An assessment of Kurenniemi's design and marketing processes

A comparison of Kurenniemi's initial design ideas with the finished instruments reveals the need for sensitivity in their analysis to whether the focus is on the *initial design idea* or the *finished product*. These analytical levels are not necessarily contradictory: they address different aspects of the same artefact and will lead to significantly different interpretations of the same subject. (See also Chapter 8.5 for more detailed discussion of different targets of analysis.)

This is exemplified in the assessment of the DIMI-T (1973), the electroencephalophone, an instrument designed to read its player's thoughts. The

changes in the field of music. I would compare it in this position to musical notation, the emergence of which in time brought composers to a whole new position. Using their sense of sight, they could perceive things that were previously only perceptible to the ear. If the internal language of a computer, the code, is understood as a kind of new musical notation, it offers musicians totally new ways of perceiving music because the music stored in the machine is not limited to any sensory area. In addition to sounds, it can be reproduced from the machine in images, movements, shapes, colors, even as smells ---.")

[446] Kurenniemi (1993a) in an interview with Ruohomäki.

[447] Kurenniemi (1970) in *Sähköinen tapahtuma Vanhalla*.

[448] Dimi Family lecture on August 21, 1978.

above-mentioned notion of a mind-reading studio could be considered one of the starting points for building the instrument. On the component level, however, it is clear that the finished instrument hardly ever used brainwave data as a control signal for an oscillator because the signal detected on the player's head was probably lost in the noise generated by the signal path due to the excessive amplification required to lift the weak EEG to a measurable level.[449] Furthermore, Kurenniemi implicitly rendered human cognition to a pale EEG in his design, which is a somewhat oversimplified presentation of complex cognitive processes.

Another typical interpretation of Kurenniemi's designs relates to the DIMI-A (1970) and its associative memory scheme. Associative in this context refers to the working logic of the instrument's memory and is thus a purely mechanical and technical term. The instrument could not form a semantic structure and retrieve information from its memory by semantic content – as an association with the human cognition metaphor might suggest (see Tiekso 2016, 406). In his utopian vision, however, Kurenniemi aimed at an instrument capable of decision-making.[450]

I have detected the following non-exclusive categories that direct descriptions and assessments of an instrument-design process in different directions during the course of this study on Kurenniemi. It depends on: 1) whether the instrument building is considered a DIY pursuit or a project aimed at making a commercial product; 2) whether the goal is to design a case-specific or a general-purpose instrument; 3) and whether the instrument is meant to be used in live performance or in the studio as a sound generator. Examining Kurenniemi's instruments from these starting points directs the interpretation of their character and the circumstances around them.

The most revealing example of how the point of departure for such an interpretation works is the assessment of Kurenniemi's failure or success, which is frequently discussed. According to the symmetry principle as defined in STS approaches, the success and failure of an artefact should be explained within the same conceptual framework: in other words, the working or non-working of an instrument is not an explanation of its success or failure, but it is something that needs to be explained (Bijker 1995, 14–15).

How Kurenniemi's failure or success is assessed depends on the above-mentioned points of departure. If one thinks of his designs as artefacts based on DIY practice intended to produce a case-specific electronic musical instrument to be included in a sound installation, for example, many of his works could hardly be described as failures. The most notable example is the Andromatic sequencer-synthesizer, which was used as part of the *Andromatic* acrylic sculpture created by Olle Adrin, Ralph Lundsten and Leo Nilsson, and featured in several exhibitions in Stockholm, New York and Östersund during 1968 and 1969. Moreover, for Lundsten the instrument was an

[449] Lehtinen, Suominen & Ojanen (2013).
[450] Kurenniemi (1973) description of digital insturments; unpublished archive document in EKA.

irreplaceable sound source in his Andromeda studio, where he used it for almost 50 years: in 2012 he declared it was “the best synthesizer in the world”[451].

On the other hand, if one evaluates the designs as potential commercial products, as mass-produced general-purpose musical instruments or music computers to be used in studios around the world as sound generators and signal processors, one would probably conclude that Kurenniemi failed to achieve his target. In the case of DEF, which succeeded together with many other non-musical-instrument-related products, this is only one side of the story. Kurenniemi’s instrument designs remained in a prototype state and the mass production never started. As Hannu Viitasalo, one of the main designers at DEF, recalls, they never ‘labbed’ the musical instruments properly[452] – referring to the testing-and-development period of the product-manufacturing life cycle in laboratory conditions before its release to customer markets. Although the linear model of innovation is criticized by proponents of socially oriented approaches, the importance of routine and a systematized prototype phase cannot be denied. However, I do not suggest adopting a linear model of Kurenniemi’s design process. I simply wish to point out how many different options were available at the time, and how the DIMI instruments evolved in a certain direction, strongly driven by trial-and-error practice, by the computer metaphor, by Kurenniemi’s experiments seeking new methods of controlling how instruments performed and by (a lack of) user experience.

Kurenniemi’s first instrument-design project, the Integrated Synthesizer, was more of a testbed than even a prototype – not to mention a finished music technological product. Trial-and-error is a typical working method in DIY-based projects. Kurenniemi exemplifies a technical culture or hobby (see Haring 2007), which was common practice among tinkerers before and after him. Evaluation of instruments in terms of sales (see Théberge 1997) and successfulness in designed-to-be-marketed and sold-as-products contrasts with DIY practice and case-specific sound installation. This is not a trivial dichotomy in Kurenniemi’s case because he also aimed at a commercial product. Tinkering was not only a DIY hobby for him. He was a figure caught between cultures recognized today as DIY versus sound art and instrument design for commercial markets. He was experimental not only in his artistic output, in other words his art works, but also in his practices and workflow development: DIY practices nowadays could be considered close to mainstream. DIY tinkerers sell their designs and modifications of established products (e.g. the DevilFish mod for TB-303, which is now adopted by the

[451] Lundsten (2012) in an interview with Ojanen & Ruohomäki.

[452] Viitasalo (2015) in an interview with Ojanen & Suominen. Nikkilä (2017; in an interview with Ojanen) also recalls that from DEF’s point of view Kurenniemi’s musical-instrument projects were only a sidetrack and did not feature in the company’s operations, which focused mainly on larger industrial-technology projects.

largest retailer of musical instruments, Thomann, which integrated the mod into its reissue of TB-303: this is an excellent example of a full circle of using user experiences to enhance the instrument-design process).

One detail that reveals the prototype state of Kurenniemi's instruments and explains the failed marketing concerns the names he gave them, which changed frequently. They even had generic names during the DEF period: DIMI derived from the concrete description of the physical artifact, DIgital Musical Instrument. This contrasts with the naming practices of Kurenniemi's contemporaries for products such as the ARP (as in Alan R. Pearlman), Moog, Buchla Music Easel and Oberheim, which derived from their designers' names. The first DEF logo appears in the research material no earlier than June 1974: promotion and branding were clearly in their infancy in the company.

Kurenniemi's instruments did not cause a technological revolution (see Lassfolk et al. 2015, 247), for one reason because of the lack of user testing. Not only was there no customer base for his designs, Kurenniemi's electronic musical instruments as products were beyond mass distribution. The situation that he and DEF were facing was not exceptional. Even the analog synthesizer did not have a customer base in the late-1960s, for example, and Moog's salespeople had to build the market from scratch (Pinch & Trocco 2002a; Pinch 2009). It was also easier to associate Moog's designs with musical instruments. In the case of DIMI, domestication was not an option.

In addition to the failed marketing to larger audiences, there were problems with the distribution of Kurenniemi's instruments even among professional users: with the exception of Lundsten, most of them eventually rejected the designs. Even though the instruments designed in DEF were directed toward large-scale industrial customers and were beyond the reach of consumer markets, Kurenniemi anticipated their mass production. He frequently described how their manufacturing could be scaled to the consumer price range. In 1972 he calculated that a one-off version of the DIMI-O would cost approximately FIM 30,000[453], although mass production would significantly lower the retail price.[454] When he presented the DIMI-S he admitted that in its technical implementation for general purposes it may have been too versatile and high-end, and the prototype's retail price would rise to a few thousand Finnish marks, but in future it could be realized with a simpler setup and the price reduced to a few hundred marks,[455] for example.[456]

[453] In 2019 approx. 40,000 Euros.
[454] See Hämäläinen (1972, 36).
[455] E.g. FIM 500 FIM in 1972 was equivalent to approx. 650 Euros in 2019.
[456] See Alanko (1972, 45).

8.3 Kurenniemi's working environment

A comparison of Kurenniemi's working environment with those of his contemporaries may explain why even the feasible elements of his utopian designs did not materialize. Most similar contemporary projects were conducted in collaboration with a fiscally responsible organization that "fitted the bill" (Bernstein 2008, 115). Elektronmusikstudion (Engl. the electronic music studio; founded in 1964) in Stockholm was developed within Swedish Radio. The main European studios in Paris, Cologne and Milan were founded in connection with the national radio corporations or official institutes. The Electronic Music Center in New York was established in cooperation with the Universities of Columbia and Princeton. The San Francisco Tape Music Center (founded in 1962) was hooked up with Mills College to receive funding from the Rockefeller Foundation. Peter Zinovieff's instrument-design projects in the UK, which he started in 1962 and developed into Electronic Music Studio (EMS, London), was a rare exception having been developed with private assets.

Composers Morton Subotnick and Ramon Sender in San Francisco were envisioning a new electronic instrument with Donald Buchla, an engineer. Inspired by the example of Columbia-Princeton Electronic Music Center, which it funded, Subotnick contacted the Rockefeller Foundation to request funding for their plans. The initial answer was that it was cheaper to fly people to New York to compose than to build a second music center in the United States. The foundation did not even grant the $500 that Buchla claimed from Subotnick and Sender for the first prototype. Eventually, after seeing the first Buchla system, the Rockefeller Foundation's advocate was convinced and in 1965 the foundation funded Subotnick's and Sender's plans to the tune of $30,000 (or $200,000 depending on the source). (Bernstein 2008, passim.)

The first drafts of Elektronmusikstudion in Sweden were laid out in detailed minutes in 1957, and official institutions such as Fylkingen were present during the planning process. There was an organizational framework – not only for providing resources but also for hosting the planning. However, it was only after Karl-Birger Blomdahl had started work as Head of the Music Department that Swedish Radio invested in the studio. Elektronmusikstudion "was assessed at a value of SEK 2.8 million" in 1970, considerably higher than the 1962 assessment in which it was valued at SEK 450,000 (Groth 2014, 95; see also Broman 2007, 66).[457]

Kurenniemi's plans for the University Studio in Helsinki were included in the annual funding applications of the Department of Musicology, signed by Professor Tawaststjerna. Each year he requested funding for the electronic components and equipment, but never for a salaried position: in other words,

[457] SEK 450,000 in 1962 was equivalent to approx. 600,000 Euros in 2019, whereas SEK 2.8 million in 1970 was equivalent to approx. 3.4 million Euros in 2019.

the university invested only in materials and not in Kurenniemi's work. As a consequence, there was lack of resources to back up the development of the studio: no official organizational planning committee was ever founded, for example. Kurenniemi worked as an unpaid – so-called voluntary – assistant. He developed and maintained the University Studio under the Department. Thereby, he was working within an organization but not within an organizational frame – something that facilitated the development of Columbia-Princeton Electronic Music Center, San Francisco Tape Music Center, and Elektronmusikstudion.

The requested funding seems inadequate given the content and target of the plans. Thus, even Kurenniemi's material resources were modest throughout the 1960s. On the other hand, working "outside" the formal organizational structure he was free to follow his own ideas. As early as in 1964 he expressed gratitude for the freedom Tawaststjerna gave him.[458] Freedom also mattered on the artistic side, which emerged when Donner compared the working environments in the University Studio and Yle.[459]

It remains unclear from the known documentary evidence why Kurenniemi was not paid for his work. Presumably, his background as a technical hobbyist and his salaried position at the Department of Physics supported a structure in which covering the cost of human resources was not considered necessary to maintain a viable working environment. In 2004, Kurenniemi recalled being very strict about not taking advantage of university money, and he did not use university resources to build his own projects.[460]

Eventually, in a funding arrangement similar to that of the San Francisco Tape Music Center, in 1970 Kurenniemi received a loan from SITRA based on a DIMI-A prototype. He needed a fiscally viable organization to get the SITRA funding, and Digelius Electronics Finland provided a structure that was similar to the one Mills College provided for Buchla, Sender, and Subotnick. It is noteworthy that not even an improved financial situation facilitated viable instrument design.

8.4 A social construction of Kurenniemi's designs

For Kurenniemi, the computer metaphor was just as strong as – or even stronger than –the association of his work with a musical instrument. Pertti Lehto, owner of the record label that released the promotional sound recording *Dimi is born* of the sequencer-synthesiser DIMI-A (1970), recalls the interest of composer Ilkka Kuusisto in whether the DIMI-A was able to print out musical scores.[461] This exemplifies the diverse meanings of technology to

[458] *Hbl* (1964).
[459] Donner (2013) in an interview with Home & Ojanen.
[460] Kurenniemi (2004) in an interview with Ojanen & Suominen.
[461] Lehto (2015) in an interview with Ojanen & Suominen.

various *relevant social groups*. As far as Kurenniemi was concerned, relevant social groups consisted of a few individuals with their own anticipations, expectations, hopes and fears of his designs. Below, I discuss a few examples.

Even though Kurenniemi designed and built the studio and the first instruments alone, in his discoveries and designs he was influenced by the social community to which he belonged. The social context was lively from the early 1960s as Finnish and Swedish composers visited and used the University Studio. As noted in previous chapters, Henrik Otto Donner, Erkki Salmenhaara, Mauri Antero Numminen and Kaj Chydenius, as well as Jan Bark, Folke Rabe, Ralph Lundsten, Leo Nilson and Osmo Lindeman, were in active contact with Kurenniemi during the 1960s. His collaboration with other artists at several events, happenings and seminars in the early years of the decade also played a significant role. It is known that composers such as György Ligeti, Luigi Nono, Karlheinz Stockhausen, Terry Riley and Ken Dewey visited Finland at that time, the two latter on Donner's initiative.

In the 1970s, during the Digelius years, Kurenniemi collaborated closely with Jouko Kottila and Hannu Viitasalo, for example, and with several Digelius employees and contemporary composers and artists. He was in contact with fellow visionaries such as Knut Wiggen (Head of Elektronmusikstudion EMS in Stockholm in 1964–1975), Manford L. Eaton (at a conference in Florence in 1968 and in later correspondence), Peter Zinovieff and Tristram Cary, and Arild Boman, who used Kurenniemi's instruments at the University of Oslo and met him several times in the 1970s. If there had been no commissioned instrument projects – starting with the University Studio, would Kurenniemi have designed his instruments, or would he have ended up as a designer of musical instruments?

For one thing, the foundation of the University Studio was in the hands of a few people. Tawaststjerna, at least, together with Salmenhaara, Oramo, and Heikinheimo played a significant role when Kurenniemi ended up designing it. Whether the true mastermind behind the idea was Tawaststjerna or the young students of musicology – Salmenhaara, Oramo, and Heikinheimo – cannot be verified from the surviving documentary evidence. Nevertheless, Salmenhaara's and Oramo's link to Kurenniemi was a crucial factor when Tawaststjerna was considering who would be suitable for executing its design and construction.

Tawaststjerna had high hopes of the University Studio, even though in the end he did not care for it.[462] The development of computer-aided analysis frequently emerged in the funding applications, the text evidently written by Kurenniemi even though the applications were posted to the university administration in Tawaststjerna's name. Some of the research-oriented computer applications may well have been written to secure official academic justification from the university administration. According to Donner, Ta-

[462] Kurenniemi (1993a) in an interview with Ruohomäki.

waststjerna had the ability so see the potential in people and to give them the freedom to realize it.[463] Even though Kurenniemi did not receive a salary for the work, he had Tawaststjerna's full support and was free to design the studio according to his own plans.[464] He built the studio and his instruments in a positive and open environment set up by Tawaststjerna.

Numminen, on the other hand, wanted an instrument for live performance with the ability to stretch cultural boundaries with unconventional musical expressions. He aimed at avant-garde and underground performances that contrasted with traditional conventions, first with Laulukone and later with Sähkökvartetti. Numminen deliberately performed classical music on the former (in the academic singing contest), following a long-established tradition. In this case he partially succeeded in expanding the boundaries as the organizers of the singing contest formed a separate category for his performance – in which he received the second prize even though he was the only competitor. The first prize went to Italian composer Luciano Berio by whom, according to the judges, Numminen had been too directly influenced.[465] Berio did not take part in the contest. (on avant-garde and underground features in the Finnish context, see also Ruohomäki 2020, EH37/4–5)

Within the underground movement, Numminen and Sähkökvartetti (the band) attacked the stagnant structures of society. The band successfully realized this aim at its premiere in Sofia when the leaders of the Communist Party walked out of the performance.[466] On later occasions Sähkökvartetti failed to cause similar ripples when their performances were received with enthusiasm rather than being frowned upon. This is illustrated clearly in a few examples. Sähkökvartetti gave a 90-minute uninterrupted performance in the Amos Anderson Art Museum, which Numminen considered its best and Oramo praised in a review in *Helsingin Sanomat*, stating that it "multiplied his belief in underground music."[467] The audience at the concert recording in the University of Helsinki's main auditorium on November 25, 1968, was audibly amused when Numminen introduced *Kaukana väijyy ystäviä*. Moreover, Sähkökvartetti performed on national TV on September 2, 1969, in a documentary about the youth generation and their role in society. None of these examples provoked public disapproval: they rather evoked a curious interest in electronic sounds and performance art. Other events of the underground movement did manage to raise objections, however. The shocking content was not related to the electronic sounds per se, neither did electronic music play a key role in the provocation.

[463] Donner (2013) in an interview with Home & Ojanen.
[464] Kurenniemi (2004) in an interview with Ojanen & Suominen; Donner (2013) in an interview with Home & Ojanen.
[465] Numminen (2018) in an interview with Ojanen; Nummi (1964, 6/*Uusi Suomi* April 6, 1964); *Uusi Suomi* (1964, 20/*Uusi Suomi* April 5, 1964).
[466] See *ESS* (August 11, 1968, 7); *Stump* (1968b, 19).
[467] Oramo (1968, 19).

Donner, who was Kurenniemi's close collaborator at the time, traveled throughout Europe several times during the first years of the 1960s. Within a brief period, he visited and worked at the electronic music studio in Bilthoven, Siemens's computer-based studio, and at the Theater of Nations in Paris with Terry Riley, who was very interested in tape loop techniques. Donner also frequently worked in the Yle studio for the radio theater, the Elektrovox studio, and in the studios of Eino Ruutsalo and Kaarlo Kaartinen. Donner's diverse experiences of studio technology were at Kurenniemi's disposal, even though he never visited the Central European studios. The interaction between Kurenniemi and Donner was intensive during the early years, and they even formed a team, according to Salmenhaara.[468] Kurenniemi experimented with the instruments, and Donner commented on the sonic output.[469]

Donner had a utilitarian approach to electronic instruments. He was less interested in how the technology worked than in what the composer or artist could achieve with it. He expected high technical quality from any equipment he used. Not unlike French composer Edgar Varèse a few decades earlier, Donner rejected electronic means altogether during the 1960s, partially due to the mediocre quality of the technology. The peak of his rejection was during a concert in Kulttuuritalo in which he wanted to turn off everything that produced an electric hum: the unexpected fully acoustic concert with a jazz group turned out to be a success, according to Donner.[470]

Despite his refusal to use electronic means, Donner did not abandon his technological optimism and expectations. As chief of Yle's music department, he played a key role in the foundation of the experimental studio, in which he also arranged the order of Kurenniemi's last musical design in the 1970s – the DIMI 6000. Donner's critical attitude on the one hand, and his expectations of technological developments on the other, clearly appear repeatedly in the documentary evidence. He criticized the state of technology in the early 1970s, but he embraced Kurenniemi's future visions and saw the future potential of technological development. He was looking forward to the future world that Kurenniemi envisioned. This is closely documented in a discussion between the two during the introduction to the DIMI-A improvisation session in *Sähköinen tapahtuma Vanhalla* on November 17, 1970. The ideas reappeared later in a radio program[471] Donner hastily produced with Ruohomäki in 1974, in which he assessed the current state of technology and described his expectations for the future.

The relevant social groups, in Kurenniemi's case individuals, could be considered the stakeholders of his designs and located in the communication

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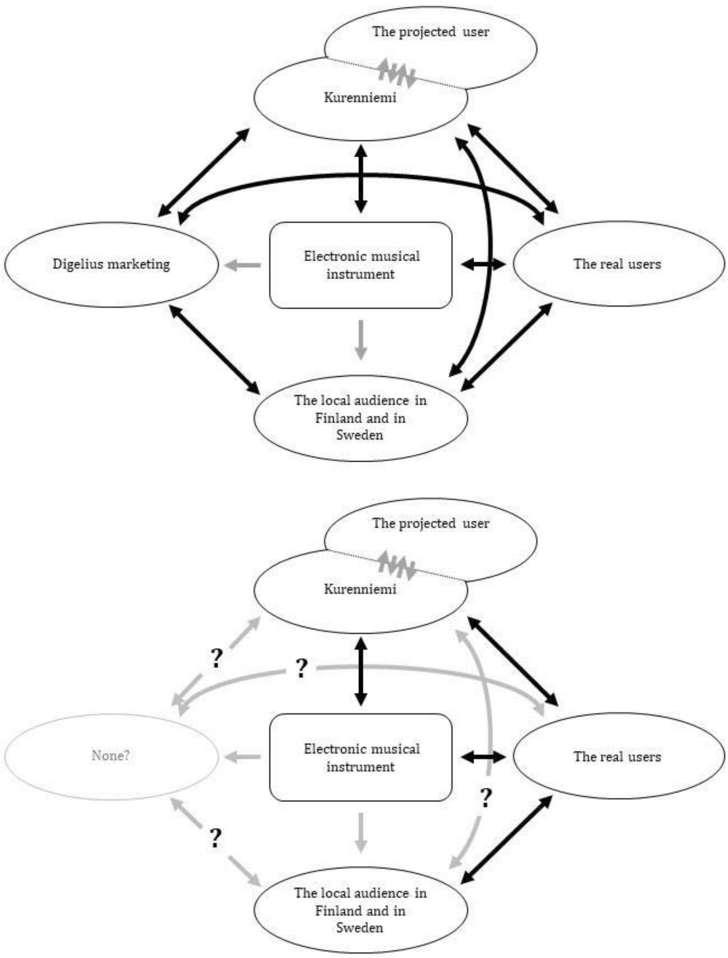
[468] Salmenhaara (1964, 55).

[469] Donner (2013) in an interview with Home & Ojanen.

[470] Donner (2013) in an interview with Home & Ojanen.

[471] Donner (1974): The radio program *Varoke* (Title: *Varoke. Käyttökulttuuriohjelmaa. Elektroninen musiikki*; Yle archive ID: 000109628).

model (see Figures 122 and 123; see also Chapter 2). In a hypothetical situation the different stakeholders involved in an instrument-design process would communicate directly with each other and via the technological artifact. In other words, all *actants* or stakeholders have their roles in a network. Given that the process of instrument design effectively develops in interaction, it is relevant to ask how this interaction was realized in Kurenniemi's case. With a few exceptions, the users worked within the technological boundaries set by the instruments on the level of both their internal configuration and their interfaces. Locating the other stakeholders in the communication model shows how the communication links between them were broken or non-existent in the real situation.



Figures 122 and 123. A hypothetical network of crucial stakeholders, in other words relevant social groups involved in the design (upper image): the links between the different stakeholders are either broken or non-existent (lower image). Here, I employ the concepts and model from the SCOT and ANT frameworks and the modern DMI analysis (see O'Modhrain, 2011). See Appendix 1 for descriptions of each of Kurenniemi's instruments. (images: Ojanen 2019)

8.5 Kurenniemi's projected users and the engagement of real users with his designs

According to Kurenniemi's utopian vision, his projected user was a composer of digital music working in a computerized music-production environment with artificial intelligence as a compositional tool. This envisioning is a tempting point of analytical departure. However, these utopian ideas did not materialize, and any analysis must be based on concrete, realized examples. The difference between Kurenniemi's projected user and the realized use situations forces the researcher to determine whether the analysis focuses on 1) Kurenniemi's initial idea for an instrument, 2) the materialized physical configuration of the instrument at the time when it was completed, 3) its configuration after 50 years of deterioration, or 4) the version of an instrument in the hands of its user.

It is worth pointing out that one is restricted to analyzing Kurenniemi's instruments in their prototype state when assessing their realized configurations, a state in which they remained due to a lack of user experience. User experiences that did not circulate back into Kurenniemi's design process – excluding those with the cumbersome DIMI-A user interface that led him to improve the interface in the DIMI-O[472] – would have influenced his designs. In this respect, even his feasible ideas materialized only in part as users only rarely explored the potential of the instruments.

Only a few examples in the research material imply that users tried to stretch the constraints of Kurenniemi's instruments or used them in a creative outside-the-box setting: there were few modifications to them. The internal configurations of the Sähkökvartetti, the DICO and the DIMI-O changed in the early phases of their life cycles, although the changes were only minor updates to fix functional deficiencies rather than major modifications. Moreover, they were fixed by Kurenniemi and not the user. In this respect, Ralph Lundsten was one of the rare exceptions when he equipped the DIMI-O with a MIDI retrofit interface introduced in the 1980s.

Kurenniemi initially designed customized instruments based on the expectations of those who requested them. He was thus in direct contact with the real user and the projection of the feasible part of his initial ideas was straightforward. If the instrument had gone into mass production, the projection might have been more complex and indirect. From the period following that of customized design, the DIMI-A exemplifies how the script in the artifact guided users to follow its initial design principle even in more indirect situations. Kurenniemi's projected user programmed the instrument step by step within the constraints of the physical artifact to produce musical sequences, and this is what real users of the DIMI-A did. Interestingly, Ruohomäki and Sakari Lehtinen from the group Cumulus used it as a metro-

[472] See Kurenniemi's unpublished presentation on his digital musical instrument in 1973 FNG/EKA.

nome, and the structure of the DIMI-A sequencer enabled Ruohomäki to control the musical events with precision when working with film music.

Ruohomäki and Vesterinen further exemplify a use case in which Kurenniemi's design gave added value to their composition process when they realized sound material for the radio play *Sähkölintupuutarha* (1971). To produce sounds that were reminiscent of the chirping of chicks they aimed the DIMI-O camera at the clouds. Thus, the subtle changes of lighting produced a stochastic trigger signal for the instrument. Another way of producing stochastic material would have been to use a computer that was not available in Helsinki at the time.

The different backgrounds of the composers and artists affected how they used and engaged with Kurenniemi's designs. Only rarely did any of them concentrate solely on one specific instrument, or consider Kurenniemi's instruments a point of departure for their artistic work – with the exceptions of M. A. Numminen with the Sähkökvartetti, Osmo Lindeman with the DICO for a brief period, and Ruohomäki in *Mikä aika on* (1970). The novelty of the instrument initially occupied almost all the attention of the users, but they gradually overcame their astonishment and employed Kurenniemi's instruments as sound sources or as part of a larger instrument setup or studio construction. This tendency is evident in the works of Ralph Lundsten, Leo Nilsson, Ruohomäki, and Lindeman.

Users accepted Kurenniemi's designs as they were – at first: then, when the instruments could no longer provide new interesting sonic aspects or points of departure for compositional decisions, they rejected them rather than attempting to modify or enhance them. An interesting question is why Kurenniemi's instruments eventually faded away while other instruments in the University Studio remained in use. According to Ruohomäki, the DIMI-A broke – or at least started to behave surprisingly.[473] Being considered prototypes and already outdated at the time of the first demonstration may have led to the conclusion that if they broke, they were not worth repairing. This supports the interpretation that Kurenniemi was looking towards the future, and resonates with Ballantine's (1977, 241) observation that experimental music is totally future oriented.

With hindsight, Kurenniemi's DIMIs offered interpretative flexibility and outside-the-box experimentation potential for music-making practices. Expectations were high, but experimentation among users was practically nonexistent, whereas composer- and work-centeredness were emphasized in the use of the instruments. Even though misuse and abuse of technology were among the key principles in Kurenniemi's own art-making and philosophy, users – interestingly including Kurenniemi – could not go beyond the constraints of the instruments. Kurenniemi's script, the intrinsic functionalities

[473] Ruohomäki (2019) in personal communication with Ojanen.

of his design, directed their use and users were unable to explore their implicit features.

8.6 Plugging electric sounds into other art forms and into society

According to many previous studies, electroacoustic music in Finland developed in two waves – the first one starting in the late 1950s and settling by the mid-1960s, and the second one starting in the late 1960s (see Lång 1990, Ruohomäki 1998; 2020; Kuljuntausta 2002; 2008). As I have previously mentioned, this is an adequate description in terms of concert activity and the number of completed works (Ojanen 2013; 2014b), but it falls seriously short if one examines the use of electronic sounds in other arts and their mentions in contemporary media. If one changes perspective from electroacoustic standalone tape music to cover a wide range of other styles, or from electroacoustic and experimental music concerts to other art forms, it is clear that the notion of phased development tells only one side of the story about the situation in the 1960s. During the assumed quiet period in the mid-1960s, Kurenniemi developed his instruments, maintained the University Studio and produced sounds, sound effects, soundscapes and even music for various productions.

In addition, his connections with his Swedish collaborators remained strong and his instruments and the University Studio played an important role, even on the Swedish scene in the mid-1960s. Leo Nilsson started to employ Kurenniemi's instruments in 1964, for example, and in 1965 he completed *Skorpionen* (1965), which was the first work produced with the instruments to be released on a sound recording. Moreover, the work was aired by Radio Andorra to honor the 84th birthday of Pablo Picasso. As Ralph Lundsten and Nilsson reveal in the sleeve notes for their first LP album, they had to travel to Helsinki to produce the electronic sequenced material they wanted because it was not possible in Sweden at the time in the modest studio facilities. The studio of Swedish Radio – eventually Elektronmusikstudion (EMS) – started to materialize only a couple of years after Kurenniemi completed his first instrument. The electronic work entitled *Kaleijdoskop* (1965), composed for the *Alarm* architecture exhibition in Stockholm in 1965, was based on concrete sounds with tape manipulation. The plan was to utilize electronic sound sources automated with a sequencer in their next exhibition work, which Kurenniemi's Integrated Synthesizer provided.[474]

Electroacoustic music was actively discussed in the contemporary media. Concert reviews from the 1960s and 1970s very strongly reflect the writers'

[474] See the sleeve notes of Lundsten and Nilsson (1966) *Elektronmusikstudion Dokumentation 1* (Sveriges Radio, LPD 1, 1966) in the Discogs database: https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Elektronmusikstudion-Dokumentation-1/release/938156.

attitudes. In Finland this was most evident in the reviews of Erkki Salmenhaara and Seppo Heikinheimo, both of whom were active concertgoers over the decades. Salmenhaara was critical of the technological quality but was usually very positive in his reviews of the new trends,[475] whereas Heikinheimo became well known for his critical and even sarcastic statements. However, even he did not spare his praise when he appreciated something. Typically, he had great expectations of Kurenniemi's designs and wrote positively about future prospects,[476] even though he tended to dismiss contemporary works and composers as poor and stagnant.

Integrating electronic sounds into other art forms was closely linked with concepts such as *intermedia* and *intermediality*, although the terms were not used in Finland until 1970. Interestingly, Kurenniemi started his music career with theater music. Unfortunately, only fragments of Ylioppilasteatteri's production of *Tintagilesin kuolema* (Engl. The Death of Tintagiles) have survived, albeit with no electronic sounds, and there are no sound recordings of the production of *Hanjo* – first in Ylioppilasteatteri (1964) and then as a TV arrangement on Mainos-TV (1964) following its re-appearance at the Finnish National Theater (1966). It is therefore impossible to give a detailed analysis of these early theater works. What we do know is that Kurenniemi's sound designs were praised in the reviews. A few years later, he continued his experiments within the theater context when the group Scene 7 used the DIMI-O to produce the music for Samuel Beckett's play *Act without words*, performed in Oslo, Norway. Still in the context of theater, Kurenniemi's instruments were frequently used and heard in radio plays, exhibitions, films, commercials and as part of dance works. What probably attracted the widest audience was the soundscape over the opening titles of the national TV news that aired throughout the 1970s: lasting only a few seconds, it was composed by Osmo Lindeman with Kurenniemi's DICO.

Among the various platforms, exhibitions in particular offered an innovative environment for experimenting with sound distribution and the technical-aesthetic setup of the display. Electronic music was reproduced from the tape in most of the exhibitions, and live instruments were rarely used in the presentations. The sounds produced in the University Studio and from Kurenniemi's first synthesizer were heard as part of the *Hej Stad!* (1966) exhibition, first in Stockholm where it reached the ears of 22,000 visitors, and later in Messuhalli in Helsinki when thousands of visitors heard electronic sounds from the University Studio – even though they probably were not aware of their origin. The work realized two years later in the University Studio, which probably attracted the most international attention, was Erkki Salmenhaara's two-piece tape collage *Information Explosion* (1967), a work on the *Man in the Community* theme of Expo 67 commissioned as part of

[475] See Salmenhaara (1967, 18 / *HS* October 31, 1967); (1969, 16 / *HS* November 19, 1969); (1970, 19 / *HS* November 19, 1970).

[476] See Heikinheimo (1972, 24 / *HS* October 20, 1972).

Montreal's World Fair from 27 April to 29 October, 1967.[477] *Information explosion* served as an acoustic canvas for 800 slides produced by interior designers Ilmari and Timo Tapiovaara. It was also the first electroacoustic work to be released on a sound recording in Finland.[478] Within the scope of this study, other notable exhibitions include *Den Immateriella Processen* and *Feel It*, of which the latter even toured in New York. Later on, national exhibitions such as *Valo ja liike 1* (1968), *Valo ja liike 2* (1969), and *Kineettisiä kuvia* (1970), and several exhibitions organized by the groups Elonkorjaajat and Dimensio distributed sounds from the University Studio widely in the national context.

The University Studio and Kurenniemi's work there did have an influence. However, it was its users – not Kurenniemi's instruments per se – who caused the impact in society. The origin of the sound material produced in there and with Kurenniemi's instruments remained unknown to the public, even though the studio was frequently introduced as such in magazine and newspaper articles. Interestingly, even though the significant contribution of the University Studio was acknowledged, it did not lead to the granting of financial support.

8.7 The diversification of valuation processes in music production

The emergence of technology-driven music production, which was facilitated by electroacoustic music practices, exemplifies how technological development can diversify valuation processes (including traditional composition). Technological developments in music, especially in the areas of sound recording, sound processing and computer technology, led to an emphasis on listening-based and process-driven working methods, and the emergence of a bottom-up composition workflow (Emmerson & Landy 2016, 10). Gradually, traditional perspectives on musical works broadened to include technology-driven, real-time and even process-based composition. In extreme cases the composer's intention was not necessarily to compose a work but to test the equipment – as exemplified in a few of Kurenniemi's works. It was only later that the sound processing and its release as an album converted the recording into a musical work. This is reflected in Talbot's (2000, 185) observation that "recorded sound has the power to turn non-works into real works".

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477 See e.g. Tawaststjerna's funding application dated 26 January 1967: "Mainittakoon, että studiossa realisoidaan parhaillaan Montrealin maailmannäyttelyyn tilattua elektronista sävellystä." (Engl. "It should be mentioned that an electronic composition commissioned for the Montreal World Fair is currently being realized in the studio.")

478 See the liner notes of LREP103. The EP was released in June 1967 (Rantanen 2005, 292). Kurenniemi is mentioned in the liner notes as a technical assistant, although according to Ruohomäki it is likely that Salmenhaara mainly worked alone.

At the time when Kurenniemi started to build his instruments (in the early 1960s), electronic music was judged by the standards of traditional classical music, even if a significant number of the new generation of composers and artists came from outside the academic, classically trained environment. This is exemplified in Lindeman, who was a classically trained composer but abandoned composing for a traditional orchestra and sought new, more direct and predetermined ways of communicating with his orchestra via the electronic medium. He soon discovered that there were similar problems in finding his own way in the world of electronic music as in traditional music. Lindeman judged his output against traditional, classical music standards. (see Ruohomäki 2020, EH37/4–5)

Donner, on the other hand, intentionally broke free from the distinction between highbrow and popular art. Even though he no longer worked in the field of experimental electronic music, he continued to explore similar themes with his Jazz-oriented group Otto Donner Treatment (OTD), the aim of which was to integrate the worlds of pop, rock, and jazz. Donner intentionally brought together musicians from distinctly different backgrounds. This is exemplified in his work *Two guitars?* (1968) for two such groups, OTD and Blues section. It is also reflected in his decision to publish an eclectic compilation album, *Perspectives '68 – Music in Finland* (1968), which comprises Salmenhaara's work for solo flute *Preludi, iskelmä ja fuuga* (1967; Engl. Prelude, Pop Tune and Fugue), Kurenniemi's *Antropoidien tanssi* (1968) and *Football* (1967) by the pop group Blues section, as well as his own *Two guitars?*.

The influence of traditional norms is also exemplified by Saunio[479] when he describes Kurenniemi as "brave to appear as a composer even though he was a mathematician", and even more strongly when he anticipated the criticism Kurenniemi would face upon entering the world of academically trained composers as an autodidact. Many of the new artists in the electroacoustic music field were self-trained, or trained engineers, not composers or artists trained in a field other than music.

Reflecting on Kurenniemi's vision of the digital composer of the future in light of the debate about the concept of a musical work, I argue that Kurenniemi did not compose musical works, he produced music. Here I return to Goehr's (1992, 186) remark that music and musical works should not be conflated. Kurenniemi exemplifies the digital composer of the future who produces on-demand music for use whenever needed. The essential feature of his musical output is its improvisatory and fleeting nature. His works could be described as manifestations of real-time interaction between physical technological artifacts such as musical instruments and their creator/user. In extreme cases he did not pay any attention to the sonic output, considering

[479] Saunio (1963, 4).

the technology and the process far more important. This is emphasized in his composition rule: “A work has to be finished in a day.”

Contradicting his view of himself as merely an instrument designer, Kurenniemi repeatedly envisioned future music-production ecosystems and the role of the digital composer in the production process. Even though he refused to consider himself an artist, he repeatedly assumed such a role or identity in his own works. He set about blurring the boundaries between art, engineering and technology, and in doing so he was one of the eclectic actors of the 1960s and the 1970s who were creating new forms of musical and sonic expression, new practices and new genres. Kurenniemi brought about realignments in art and technology, but not in economics, politics or gender roles (see Pinch 2009, 190, for example, on the concept of re-alignment).

Kurenniemi’s refusal to call himself a composer reflected the traditional definition of the term, and a new definition was called for in the 1960s. Along with the slow shift in paradigm from music to sonic art, a new kind of engineer-artist role started to develop. Kurenniemi explicitly described his designs as moving towards a new understanding of music production even in the early days. He anticipated a trend that would position the composer as a producer rather than an author, explaining in 1964 that the composer was becoming closer to the conductor of the orchestra.[480] Nevertheless, in the same year Salmenhaara described Kurenniemi as a composer.[481] Interestingly, Kurenniemi included the title of composer in his CV later in the 1970s, explaining in his diary that he was starting to use the artist role to facilitate or accelerate the marketing of his instrument. He wanted to identify himself as a composer after all.

Within his local context, it seems that Kurenniemi was the only one who could accept the idea that any sonic manifestation could be considered musical material. Numminen with his avant-garde works came close, but Kurenniemi was only able to overcome the need for a prescribed plan with his Sähkökvartetti improvisation. Among classically trained composers, both Lindeman and Romanowski wanted to design a system or to formulate a language of a sort to support their musical works. Romanowski relies on testing and improvisation only during the brainstorming phase of his composition process, believing that improvisation per se, in other words without a context or a justified reason, is not interesting enough for the listener.[482] He approves of documenting improvisation only for research purposes – not for artistic purposes. He composes his tape music works strictly according to a prescribed plan, the building blocks being processes, ideas, systems, or sound fields.

Very similar tenets directing Lindeman’s working method are reflected in his comments when he retrospectively assessed his electroacoustic music

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480 *Hbl* (1964; 1, 11).

481 Salmenhaara (1964, 55); see also *Hbl* (1964; 1, 11).

482 Romanowski (2019) in an interview with Ojanen.

repertoire in 1975: he described his early works as studies rather than official compositions, which should be ignored. He further explained that he was too easily satisfied with his early works. This differs from Kurenniemi's attitude. After studying further and focusing on electronic music composition, Lindeman gradually revealed his background as a traditionally trained composer. In the end, he did not see any difference in the processes of composing traditional and electroacoustic music – in general.

Whereas other composers and artists are located on the same map, it is clear that Ruohomäki exemplifies an actor who acknowledges the importance of the poietic ecosystem, but his interactive-listening mode of working with the technology places the emphasis on the sonic output, that is, on the material reality of the work. He denies that his music has a program. In emphasizing this he wishes to step away from defining how people should listen to his works, even though he gives them distinctively descriptive names: *Pisces*, for example, has a clear reference to water, and the sonic nature of the work is strongly mimetic in this sense.

Going against Kurenniemi's utopian vision, Ruohomäki did not automate the studio. He programmed Kurenniemi's sequencers, but technological constraints such as the DIMI-A's memory forced him to rely on traditional electronic music techniques of tape manipulation – something that Kurenniemi tried to overcome even though he was faced with the same constraints. Ruohomäki's emphasis lies somewhere between the work and the poietic ecosystem. For Donner, in turn, the esthesic side was clearly more dominant: his interest was not in how the technology worked, but in what the user could achieve with it.

It is thus clear that Kurenniemi was an innovator not solely for the avant-garde but for any art practices. The electronic medium provided a platform on which the boundaries between high and popular art were frequently crossed. However, the differences among the actors emerge in their attitudes towards composition principles, not electronic means. Even though electroacoustic music provided a neutral platform and a chance to break free from traditional categories of high and low, or arty and popular, the genre and its development exemplifies how the tool, in other words electronic means, is only a tool and the valuation process is based on users' attitudes. Technology could be considered neutral – even though this has been debated – but as soon as it is in the hands of users, it turns into a projection of the user's attitudes, goals, expectations and wishes – just as music and musical works are signified via contextualization. Similarly, as with musical works and how they relate to their production and reception, Nattiez's tripartition could be used to describe music technological artifacts.

Electroacoustic music is electronically mediated. The medium enables the detachment of the content and its management from the composer's immediate control. Technology-driven music production diversifies[483] the workflow from user-centeredness to media-centeredness. Electroacoustic music made it possible to surpass the orchestra and the conductor as the interpreter or mediator. Kurenniemi aimed even further. For him, music technology made it possible to surpass the intention of the composer and the composer's mental schema, or the music technology as a physical mediator, and thereby to transform the composer's mental schema directly into musical output. It facilitates a shift in the workflow, first, to listening-based real-time processes, and then even to fully technology-driven processes. (see Figure 124) This is where the valuation of music production diversified along with the technological development. Only a few composers and artists were ready to accept the new, radical method in which the composer's mental schema and educational background do not play a key role – the value judgements are ubiquitous.

Kurenniemi's work exemplifies close interaction between music and technology on the one hand, and the role of the electronic medium in the early days of value-free music production on the other. Here, I refer to the situation in the 1960s when contemporary technology provided a new aesthetic tool to be utilized in both popular and art-music contexts. However, any instrument is similarly used in various contexts, in various styles and genres, and for different purposes. As I have shown in this study, value-free music production soon vanished whereas the attitudes of composers and artists, directed by their background, re-emerged to judge what is good, bad, acceptable or forbidden in electroacoustic music.

[483] Diversification does not change or exclude previous compositional process, it rather broadens or adds things to them. One should ask how the technological development broadened and enhanced music production rather than how technology changed it. Old attitudes and techniques persist, while something new is added.

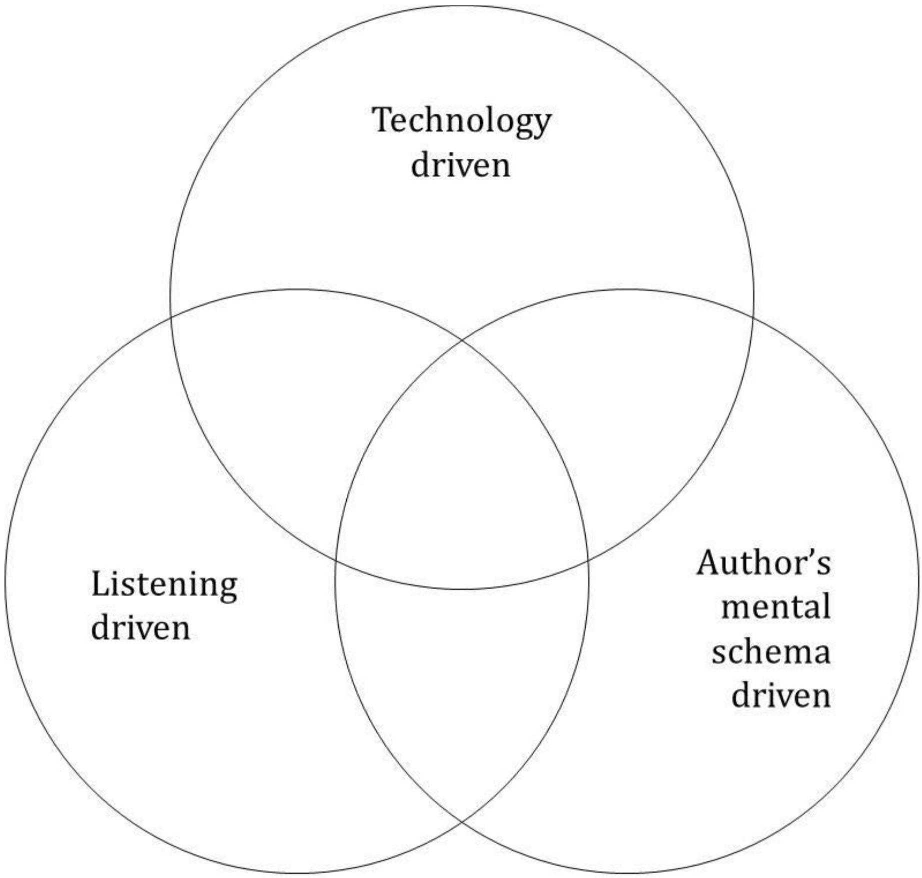

Figure 124. The author's (composers, producers, or artists) three attitudes towards the music-production process. Most of the composers acquired all or at least two of the three attitudes, however this is where they differ. Some accept purely technology-driven content in their work more readily than others, and others emphasize the composer's control over all parameters and musical events (located mainly in the bottom-right circle). Composers also differ in how much they emphasize their own aesthetic decision-making. In some sense, music production driven by technology and the author's mental schema can result in a musical work with a sonic outcome that is secondary to the system driving the production process. (image: Ojanen 2019)

9 CONCLUSIONS

This study provides new insights into electronic and electroacoustic music in Finland between 1961 and 1978. I have examined the period through the works of composers and artists who used the unique electronic musical instruments designed by Erkki Kurenniemi, the Finnish pioneer of electronic music. Kurenniemi's work as an instrument designer and artist was the point of departure for this interdisciplinary study, in which I consider the phenomenon from historical, technological and musical perspectives. My analyses of the user interfaces of Kurenniemi's instruments and the stories of their users reveal the complex networks of 1) technological artifacts with their explicit and implicit features and functionalities, 2) users with their attitudes and value assessments, and 3) cultural and historical contexts such as musical traditions and genres, in which all the components are seamlessly intertwined. Kurenniemi did not invent and develop his instruments in an isolated laboratory, and his social network played a significant role in both the successes and failures of his musical adventure.

On the *historical level* I show how understanding of the past is relative, and that constant re-evaluation based on new discoveries in the source material is needed. This study presents a large amount of new and significant documentary evidence. Credible conclusions and interpretations can only be based on systematic and thorough research. As I point out, for example, interpretation of the two waves in the development of electroacoustic music in Finland is tenable only within a certain scale of observation. The idea of two waves is a later construct that is detached from the target of this study – something that was conjured up afterwards. Upon closer examination of Kurenniemi's oeuvre, based on Giovanni Levi's *scale of observation*, the research material reveals that throughout the 1960s he worked continuously on his designs, which were then utilized by composers and artists in various art works – across genres.

Furthermore, the division into two periods reflects the researcher's choice to classify the musical genre according the production methods used to create the works. Research results vary depending on the assumed role of technology in music production. The adoption of production technology as a point of departure for the classification directs the research in a different direction than starting from the pure aesthetic output of music – neither of which is wrong. Such choices also influence the definition of and discussion about electroacoustic music. To relate the musical genre entirely to the production technology is to dismiss both the intention of the composer and the interpretation of the listener. The value of an instrument or a production is defined by its users, not by the medium per se. Researchers who set their goal to trace works produced by electronic means form a different picture of the period than those who wish to trace the overall stylistic development of a certain group of composers.

Tracking the use of electronic technology in music production and composition without proper musical and cultural-historical analysis may even skew the conception of the music culture of the time. As Landy (1999, 64) points out, the history of electroacoustic music is "not solely technology based or even necessarily technologically driven." The electronic means used in music production and composition vary from one composer to another. Kurenniemi was deeply involved in his instrument design, for example, whereas his close collaborator, Henrik Otto Donner was mainly interested in the sonic outcome of a musical work: for him, the production methods and media were secondary to the musical expression. Classifying both in the electroacoustic music category reveals little about their musical similarities and differences.

On the *technological level*, in studying both the development and the use of Kurenniemi's electronic musical instruments I show how the target of a study can dictate the research results. This is exemplified in the current study by the assessment of Kurenniemi's designs and their implementation. Kurenniemi was a successful designer of musical instruments, finding solutions that facilitated the work of several composers and artists in various fields of music, art and technology during the 1960s and 1970s. His utopian dreams were welcomed enthusiastically by his contemporaries, but their implementation, the materialized version of his designs, remained only half-completed. The user experiences did not circulate back to his design process and he could not take full advantage of the relevant social groups who appreciated his work. Eventually, users of his instruments could not get beyond the constraints, and many even rejected them. Here, the assessment of Kurenniemi's work depends on whether his designs are considered case-specific electronic musical instruments and outcomes of a DIY culture, or prototypes of viable commercial products. In fact, they were both.

On the level of *music aesthetics*, it is more fruitful to ask how technology diversified music-production processes and their valuation rather than how it changed music. On the basis of this study I argue that technological development did not change music or musical practices. It was the various actors – designers, composers, users, artists, listeners, and audiences – who decided whether or not they accepted the new means. Technology only sets the framework within which users operate, guided by their attitudes and points of departure. Aesthetics is also socially constructed.

Using the theoretical and methodological toolbox borrowed from music, technology and history studies I have presented a holistic description of electroacoustic music in Finland in the 1960s and 1970s. However, to ensure a thorough understanding the theoretical and material triangulation discussed above should be complemented with interdisciplinary triangulation. I was fortunate to conduct my research in a technology-minded environment. The related projects of my fellow Kurenniemi enthusiasts Jari Suominen and Kai Lassfolk complement my own work. Moreover, the opportunity to use Kurenniemi's instruments in performance together with my colleagues has broadened my points of view. Even though I do not employ artistic research methodology in my work, performing with the research subject had a profound effect both on the questions I asked, and on my interpretation based on them.

Framing the study is necessary and only a narrow point of view can be acquired at any one time. The world did not end in 1978, which marked the end of my observations. Neither did the target of this study arise from out of nowhere in 1961. Moreover, the period in between, which I examine here, should be further elaborated. Amid artistic research, the material I present in this study would benefit from other methodological approaches, such as those represented by media archeology, art history, sociology, or gender studies – to mention but a few. Contextualization with closer analyses of economic and political structures would also enrich this description.

Two interrelated themes that specifically deserve a closer look in the future are intermedia and societal impact, in other words how electric sounds were incorporated into different art forms and into society. This study constitutes a point of departure for these themes. The University Studio and Kurenniemi's instruments played a significant role in providing electronic sounds for various kinds of art works, which were then distributed into contemporary society. An interesting collection of documentary evidence with the potential for further research emerged from the archive material analyzed within this study. For example, the sounds made by Kurenniemi's instruments on sound recordings provide an interesting framework, with a set of source material that is considerably larger than previously known. The mere visibility of a cultural artifact in society does not equal its impact, however, but the concept of impact requires a detailed definition. In addition, the composers and artists and their unique and original work, which I mention only briefly in this study, deserve their own, interrelated chapters in books on electroacoustic music history. A detailed look into these themes could provide new insights for those interested in the question of nationalism.

According to the modern historiographical paradigm, it is acknowledged that everything has a history, and whatever it is, it is entitled to be written. Its description may be based on various, fragmented and even surprising sources, not only official documents. Rahikainen & Fellman (2012) defend the right of historians to access proper documentary evidence, in other words the research should be transparent, repeatable and based on archival work. Given the extensive qualitative research material and data behind several modern research projects, it is ever more important to support and secure the right of researchers to their data and its management.

On this issue in particular, I have great expectations of the digital tools and methods, such as linked and big data, that are rapidly emerging in humanities and history studies. Machines cannot do the research, but they can open up avenues to new points of view and interpretation.

To facilitate the research community's right to proper and transparent documentary evidence, I have made the material and data I have processed within this study as openly available as possible. I have used the study to pilot an approach to the management of research data comprising complex material related to cultural heritage and the arts. I am committed to open science and research ideology. Technologically informed analysis and history writing will continue in cultural-heritage projects such as Finnish ElectroAcoustic Research Sources (FinEARS).

As I point out in this study, research on Kurenniemi exemplifies how diverse approaches produce different descriptions – complementary rather than exclusive. Thus, there is a need for more researchers, more research material, new tools and more points of view to draw a comprehensive picture of electroacoustic music in Finland – and of *Finnish* electroacoustic music. The work continues.

REFERENCES

Source material and research data

Archives and collections

Amos Anderson Art Museum archive

Erkki Kurenniemi archive in the Finnish National Gallery (FNG/EKA)

Helsingin Yliopiston Ylioppilaskunta (HYY) archive (University of Helsinki Student Union archive)

Jouko Kottila archive (private archive)

Jukka Ruohomäki archive (private archive)

Kielipankki (The Language Bank of Finland holding FinEARS Interviews)

Lehtikuva archive

Leo Nilsson archive (private archive)

Music Finland archive (incl. Jukka Ruohomäki's digitizations of electronic works)

Kansallisarkisto (National Archive; holding Digelius Electronics Finland documents)

Kansalliskirjaston kokoelmat (National Library of Finland collections; incl. digi.kansalliskirjasto.fi)

Osmo Lindeman archive (private archive)

Oulu Sinfonian arkisto (Oulu Symphony Orchestra archive)

Pekka Hoikkala archive (private archive)

Pekka Sirén archive archive (private archive)

Ralph Lundsten archive (private archive)

Risto Rautee archive (private archive)

Teatterimuseon arkisto (Theater Museum archive; TeaMA)

University of Helsinki Music Research Laboratory and Electronic Music Studio (UHMRL) archive

Yleisradion arkisto (Finnish Broadcasting Company archive; Yle)

Ylioppilasteatteri archive (Helsinki Student Theater archive located in TeaMA)

Archive material (unpublished)

The Finnish National Gallery / Erkki Kurenniemi archive

Kurenniemi's audio diaries C4000, C4060, C4113, C4136, C4137, C4138.

Kurenniemi, E. 1971. The written instructions for *Deal*, in Finnish (October 1971), in English (October 26, 1971).

Kurenniemi, E. 1972. DIMI-päiväkirja 1971–1972.

Kurenniemi, E. 1973. Description of digital instruments.

Kurenniemi’s letters and correspondence.

Oramo, I. 1971. The program of the Nordisk seminar and Oramo’s talk.

Wahlström, E. 1971. letter to Kurenniemi about the acceptance of the work for the Nordic Music Days.

The National Archive of Finland

Journal number: 1406/178-70.

Leo Nilsson archive

The invitation card of *Den Immateriella Processen* in Leo Nilsson archive.

Music Finland archive

Donner, Henrik Otto. 1962. *Ideogramme I.* https://core.musicfinland.fi/works/ideogramme-i

Donner, Henrik Otto. 1963. *Ideogramme II.* https://core.musicfinland.fi/works/ideogramme-ii

Donner, Henrik Otto. 1963. *Ideogramme For Emmy 2.* https://core.musicfinland.fi/works/for-emmy-2

Salemenhaara, Erkki. 1963. *Concerto per due violini.* https://core.musicfinland.fi/works/concerto-per-due-violini

Music Finland sound archive digitized by composer Jukka Ruohomäki; CD signums for example: CD5261.

Oulu Symphony Orchestra’s archive

Oulu Symphony Orchestra’s concert program 18.10.1972. https://doi.org/10.5281/zenodo.4290669

Theater Museum archive

The minutes of a meeting of the executive committee of Ylioppilasteatteri held on January 15, 1963 (TeaMA1487: Cb:2).

The minutes of a committee of meeting held on February 6, 1963 (TeaMA1487: Cb:2).

The Ylioppilasteatteri's annual report of 1963 (TeaMA1487: Db).

Ylioppilasteatteri executive committee minutes, May 4, 1963 / TeaMA1487: Cb:2).

The University's Archive and Registry

The University of Helsinki Register of Faculty of Science.

The University of Helsinki Register of Students.

The University of Helsinki Music Research Laboratory (UHMRL) archive

The composer brochure of Osmo Lindeman (FIMIC 1979) in the UHMRL archive.

Erkki Kurenniemi's daily planner, 1969 in the UHMRL archive.

Erkki Kurenniemi's daily planner, 1971 in the UHMRL archive.

The balance sheet and annual report of Digelius Electronics Finland in Jouko Kottila's private archive; copy in the UHMRL archive.

The UHMRL digital tape archive; tape IDs for example: 20180711_01

The DIMI Family lecture audio recording in the UHMRL archive.

The inventory catalogue of the University Studio in the UHMRL archive.

The DIMIX specifications in the UHMRL archive.

The DIMIX purchase documents in the UHMRL archive.

The Department of Musicology annual funding applications by Erik Tawaststjerna (1967; 1970; 1971) in the UHMRL archive.

The Digelius briefing program, January 20, 1971 in Jouko Kottila's private archive; copy in the UHMRL archive.

The University of Helsinki Student Union archive

The HYY executive committee meeting minutes on June 19, 1968

H_Hga_2_680530_sopimus. https://doi.org/10.5281/zenodo.4290688

H_Hga_2_680530_sopimus_liite. https://doi.org/10.5281/zenodo.4290688

Audio-visual recordings, radio programmes, films and documentaries

Anon. 1975. *Kika-digga-ding*. [School TV program]. https://www.youtube.com/watch?v=VfDr9zaO_TQ.

Aaltonen, Kajander, Lampila, Marttila, Saar, Vehniäinen. 1969. *Otto Donner*. (Materiaalinauha = material tape). [Documentary film]. Helsinki: Yle's education office. Yle's archive; Media ID: MEDIA_2015_00923242; Program ID: PROG_2009_0035191.

Craig, D. 2007. *Ligeti – Artikulation. Visual listening score*. https://www.youtube.com/watch?v=71hNl_skTZQ.

Donner, O. et al. 1970. *Sähköinen tapahtuma Vanhalla* [A radio program]. Yle's archive ID: 000053962.

Donner, O. 1974. *Varoke: Käyttökulttuuriohjelmaa. Elektroninen musiikki*. [A radio program]. Yle's archive ID: 000109628.

Donner, O. & Vesterinen, M. 1971. *Viherä elain*. [A radio play] Yle's archive ID: 000096478.

Fantinatto, R. 2017. *SUBOTNICK: Suzanne Ciani on Morton Subotnick*. [Video/DVD]. https://www.youtube.com/watch?v=-Rj6IJBR77g&list=PL2aIqCqnqukLN8dGhMYmJOeLigcziHIJo&index=35

Heikinheimo, H. 1971. *DIMI-baletti* [Documentary] Yle archive document; Name of the program: DIMI-baletti. Media ID: MEDIA_2014_00760531; Program ID: PROG_ 2009_00206150. Created: 19710922. Producer: Hannu Heikinheimo.

Jarva, R. 1968. *Tietokoneet palvelevat* [Computers serve; Commercial film]. Helsinki: Filminor. https://www.elonet.fi/fi/elokuva/601470. https://elavamuisti.fi/aikajana/tietokoneet-palvelevat.

Jarva, R. 1969. *Pakasteet II* [Frozen food; Commercial film]. Helsinki: Filminor. https://www.elonet.fi//fi/elokuva/640415. https://elavamuisti.fi/aikajana/pakasteet-ii.

Lindeman, O. 1969. *Computer Music for Stereophonic Tape*. Yle's archive ID: 000102029.

Lindfors, J. 2008. *DIMI, suomalainen syntetisaattori*. https://yle.fi/aihe/artikkeli/2008/03/18/dimi-suomalainen-syntetisaattori.

Nono, L. 1960. *Omaggio A Emilio Vedova*. https://youtu.be/8WAjjtNVVKg.

Ojanen, Mikko. 2018. *Arrangement of J.S. Bach's Invention No. 13 in A minor (BWV784) for the DIMI-A synthesizer by Erkki Kurenniemi (1970): An annotated video of the master tape*. https://vimeo.com/278832133.

Oura, A. 1967. *Kahdeksan tahtia tietokoneelle* [Documentary film] Yle's archive document; Name of the program: Kahdeksan tahtia tietokoneelle (Engl. Eight bars for a computer). Media ID: MEDIA_2012_00467326; Program ID: PROG_2009_00123373. Director: Aki Oura.

--- 1969. *Ihmisen uudet mahdollisuudet* (Engl. The new possibilities of man). [Documentary] Yle's archive document; Media ID: MEDIA_2014_00772238; Program ID: PROG_2009_00121250. Director: Aki Oura.

Ritavuori, H. 1969. *Maan aurinko* [Documentary] Yle's archive document; Name of the program: *Maan aurinko* (Engl. Sun of the Earth). Media ID: MEDIA_2014_00768009; Program ID: PROG_2009_00105005. Director: Heikki Ritavuori.

Ruohomäki, Jukka. 1993. *Ihmisiä, koneita ja musiikkia*, [A radio program; Engl. Men, Machines and Music]. Yle Archive ID: DIG-390965-0.

Ruutsalo, E. 1965. *Hyppy* [Movie]. https://www.elonet.fi/fi/elokuva/129895

Schreck, J., & Kokkonen, E. 1964. *Hanjo* [TV Movie]. https://www.imdb.com/title/tt1454005/.

Sima, J. 1973. *Cosmic Love. Ralph Lundsten elektrontonsättare*; Ett porträtt av Jonas Sima. [Documentary]. http://www.svenskfilmdatabas.se/sv/item/?type=film&itemid=56455; http://www.sima.nu/film-cosmic.htm.

Taanila, M. 2002. *Tulevaisuus ei ole entisensä*. [Video/DVD] Helsinki: Kinotar.

--- 2003. *The dawn of DIMI*. [Video/DVD] Helsinki: Kinotar.

--- 2007. *Aika & aine = Time & matter*. [Video/DVD] Helsinki: [Pan Vision] [jakaja].

Tenney, J. 1961. *Analog #1 (Noise Study)*. https://youtu.be/fe4UlyQAgcc.

Vainio, R. 1972. *Musiikkiykkönen: Hummerit ja hummarit. Hummarit ja hammarit*; Media ID: MEDIA_2016_01094581; Programme-ID: PROG_2009_00171786; Date: 19721006.

Yli-Ojanperä, E. 2013. *Futuristisella matkalla ylihuomiseen* 1971. https://yle.fi/aihe/artikkeli/2013/05/30/futuristisella-matkalla-ylihuomiseen-1971#media=96419.

Vesterinen, M. & Kari, A. & Ruohomäki, J. 1974. *Sähkölintupuutarha*. [Movie]. Helsinki: Tööt-filmi. https://elonet.finna.fi/Record/kavi.elonet_elokuva_153068.

Interviews

Andersson, Åke, Honkanen, A., & Kuljuntausta, P. 2018. [Interview with Åke Andersson and Antero Honkanen by Petri Kuljuntausta in November 2015]. In Andersson, Åke & Honkanen, A. *Reidarin sähköiset kuvat: Åke Anderssonin ja Antero Honkasen elektronimusiikkia*. Svart Records – SRE 129.

Bentley, Andrew, & Ojanen, M. & Lassfolk, K. 2015. Interview with Andrew Bentley by Mikko Ojanen and Kai Lassfolk 4.11.2015, The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finn-*

ish electroacoustic music interviews [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

--- 2019. Interview with Andrew Bentley 28.–30.9.2019. By Mikko Ojanen, Email conversation. https://doi.org/10.5281/zenodo.4289358.

Davidow, Joe, & Ojanen, Mikko. 2019. Interview with Joe Davidow by Mikko Ojanen 8.3.2019. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Donner, Henrik Otto, & Ruohomäki, J. 1994. Interview with Henrik Otto Donner by Jukka Ruohomäki 7.9.1994. In Jukka Ruohomäki archive.

Donner, Henrik Otto, & Home, M., & Ojanen, M. 2013. Interview with Henrik Otto Donner by Marko Home and Mikko Ojanen 29.4.2013. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Hakala, Kari, & Lassfolk, K., & Ojanen, M. 2013. Interview with Kari Hakala by Mikko Ojanen and Kai Lassfolk 18.11.2013. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Karlsson, Cay, Lehtinen, S., & Riihimaa, J. 2018. Sirkustirehtöörin pieni sydän – musiikillisia muistoja: [Interview with Cay Karlsson and Sakari Lehtinen in the Fall of 2016]. In Cumulus, *Sirkustirehtöörin pieni sydän*. Svart Records – SRE153.

Kottila, Jouko, & Lassfolk, K., & Suominen, J., & Ojanen, M. 2014. Interview with Jouko Kottila by Kai Lassfolk, Jari Suominen and Mikko Ojanen 16.6.2014. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Kurenniemi, Erkki, & Oura, A. 1967. Interview with Erkki Kurenniemi by Aki Oura in October 1967. By Aki Oura. The University of Helsinki Electronic Music Studio, Vironkatu. In *Kahdeksan tahtia tietokoneelle* (Engl. Eight bars for a computer). Document in Yle's archive; Media ID: MEDIA_2012_00467326; Program ID: PROG_2009_00123373.

Kurenniemi, Erkki, & Oura, A. 1969. Interview with Erkki Kurenniemi by Aki Oura March 1969. Location unknown. In *Ihmisen uudet mahdollisuudet* (Engl. The new possibilities of man). Document in Yle's archive; Media ID: MEDIA_2014_00772238; Program ID: PROG_2009_00121250.

Kurenniemi, Erkki, & Ruohomäki, J. 1993a. Interview with Erkki Kurenniemi by Jukka Ruohomäki 28.10.1993. The University of Helsinki Electronic Music Studio, Vironkatu. In Jukka Ruohomäki archive.

Kurenniemi, Erkki, & Ruohomäki, J. 1993b. Interview with Erkki Kurenniemi by Jukka Ruohomäki 19.11.1993. Heureka. In Jukka Ruohomäki archive.

Kurenniemi, Erkki, & Suominen, J., & Ojanen, M. 2004. Interview with Erkki Kurenniemi by Mikko Ojanen and Jari Suominen 29.5.2004. The University of Helsinki Electronic Music Studio, Vironkatu. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Lehtinen, Jari, Jari Suominen and Mikko Ojanen. 2013. An email conversation between Jari Lehtinen, Jari Suominen and Mikko Ojanen June 14, 2013. In Mikko Ojanen archive.

Lehto, Pertti, & Suominen, J., & Ojanen, M. 2015. Interview with Pertti Lehto by Mikko Ojanen and Jari Suominen 14.12.2015. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Lindeman, Osmo, & Koskimies, A.-N. 1972. Interview with Osmo Lindeman by A-N Koskimies, Radio interview. Recording in UHMRL archive.

Lindeman, Osmo, & Paalanen, L. 1974. Interview with Osmo Lindeman by Leena Paalanen, Musiikkikellariohjelma. Recording in UHMRL archive.

Lindeman, Osmo, & Santalahti, L. 1980. Interview with Osmo Lindeman by Leena Santalahti 1980. Recording in UHMRL archive.

Lindeman, Osmo, & Sermilä, J. 1975. Interview with Osmo Lindeman by Jarmo Sermilä 5.2.1975. Recording in UHMRL archive.

Lindeman, Sirkka, & Ruohomäki, J. 1996. Interview with Sirkka Lindeman by Jukka Ruohomäki 8.5.1996. In Jukka Ruohomäki archive.

Lundsten, Ralph, & Ruohomäki, J., & Ojanen, M. 2012. Interview with Ralph Lundsten by Mikko Ojanen and Jukka Ruohomäki 13.6.2012. Andromeda studio, Stockholm. In Mikko Ojanen archive.

Lundsten, Ralph, & Ojanen, M. 2018. Interview with Ralph Lundsten by Mikko Ojanen 2018–2020. https://doi.org/10.5281/zenodo.4289353.

Nikkilä, Seppo, & Ojanen, M. 2017. Interview with Seppo Nikkilä by Mikko Ojanen 11.3.2017. Marbella / The University of Helsinki. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Nilsson, Leo, & Ojanen, M. 2019. Interview with Leo Nilsson by Mikko Ojanen 2019–2020. https://doi.org/10.5281/zenodo.4271167.

Numminen, M. A., & Ojanen, M. 2018. Interview with M.A. Numminen by Mikko Ojanen 8.3.2018. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Rautee, Risto and Pekka Hoikkala, & Ojanen, M. 2017. Interview with Risto Rautee and Pekka Hoikkala by Mikko Ojanen 19.4.2017. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Romanowski, Otto, & Ojanen, M. 2019. Interview with Otto Romanowski by Mikko Ojanen 13.2.2019. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Ruohomäki, Jukka, & Suominen, J., & Ojanen, M. 2004. Interview with Jukka Ruohomäki by Mikko Ojanen and Jari Suominen 3.12.2004. The University of Helsinki Electronic Music Studio, Vironkatu. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Ruohomäki, Jukka, & Ojanen, M. 2014. Interview with Jukka Ruohomäki by Mikko Ojanen 15.–16.5.2014. The University of Helsinki Electronic Music Studio, Topelia. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

--- 2018. Interview with Jukka Ruohomäki by Mikko Ojanen. 2018. Oulunkylä. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Salmenhaara, Erkki, & Sermilä, J. 1975. Interview with Erkki Salmenhaara by Jarmo Sermilä 17.2.1975. In Jukka Ruohomäki archive.

Vesterinen, Marja and Jukka Ruohomäki, & Paavolainen, T. 1971. Interview with Marja Vesterinen and Jukka Ruohomäki by Tytti Paavolainen 19.11.1971. The University of Helsinki Electronic Music Studio, Vironkatu. Yle Archive ID: 000059535

Viitasalo, Hannu, & Suominen, J., & Ojanen, M. 2004. Interview with Hannu Viitasalo by Mikko Ojanen and Jari Suominen 4.11.2004. Helsinki-Vantaa Airport. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

--- 2015. Interview with Hannu Viitasalo by Mikko Ojanen and Jari Suominen 23.11.2015. The University of Helsinki Electronic Music Studio. In Ojanen, Mikko. 2020. *Finnish electroacoustic music interviews* [corpus]. Kielipankki. Available: http://urn.fi/urn:nbn:fi:lb-2020030421.

Newspaper and magazine articles, contemporary historical documents and retrospective memoires

Amos Andersonin taidemuseo. 1969. *Valo ja liike 2: kansainvälinen kineettisen taiteen näyttely: Amos Andersonin taidemuseo, Helsinki, 10.5.–8.6.1969 = Ljus och rörelse 2: internationell utställning av kinetisk konst: Amos Andersons konstmuseum, Helsingfors, 10.5.–8.6.1969 = Light and movement 2 : international exhibition of kinetic art*. (Amos Andersonin taidemuseo. Luettelo ; no 42). Helsinki: Amos Andersonin taidemuseo.

Ahlgren, Stig. 1970. “Kärleksmaskinen.” *Svenska dagbladet*, 31.7.1970, 7.

Ala-Könni, Erkki, Gothóni, A., Kaurinkoski, T., Nieminen, M., & Virtamo, K. 1977. *Otavan iso musiikkitietosanakirja*. 2, Dallapiccola – Hervé. Helsingissä: Otava.

Ala-Könni, Erkki, Granholm, H., & Kaurinkoski, T. 1978. *Otavan iso musiikkitietosanakirja*. 4, Laulu – Rantasalo. Helsingissä: Otava.

Alanko, Jouko. 1972. "Musiikkia Seksofonilla." *Tekniikan Maailma*, 18/1972, 44–45.

American Craftsmen's Council. Museum of Contemporary Crafts. 1969. *Feel It – Press Release* https://digital.craftcouncil.org/digital/collection/p15785coll6/id/6547/rec/2.

--- 1969. *Feel It* [catalog & sound recording]. https://digital.craftcouncil.org/digital/collection/p15785coll6/id/5876/.

Arpiainen, Leila. 1966a. "Koristeellinen'Hanjo'". *Helsingin Sanomat*, 8.7.1966, 13.

--- 1966b. "Tarinaa idästä ja lännestä." *Helsingin Sanomat*, 22.9.1966, 16.

Bakerich, F., & Scully, R. 1973. *Electroencephalophone and feedback system* (US3753433 ed.). https://www.google.com/patents/US3753433.

Bentley, Andrew. 2017. *Historical electronic music by Andrew Bentley 2*. https://algorithmicsound.com/2017/03/03/historical-electronic-music-by-andrew-bentley-2/.

Brandel, Åke 1971. "Dom tänder på varandra med kärleksmaskin!" *Aftonbladet*, 1.8.1971, 7.

Buchla Associates. 1966. *The modular electronic music system*. Berkeley: Buchla Associates.

Chydenius, Kaj. 1963. "Musik utan musiker." *Hufvudstadtsbladet*, 2.4.1963, 6.

Dahlberg, Olof. 1968. "Ljus och ljud som tvärkonst." *Dagens Nyheter*, 10.11.1968, 6.

Davies, Hugh. 1968. *Répertoire International Des Musiques Electroacoustiques: International Electronic Music Catalog*. Cambridge, Mass.: MIT.

DN = Dagens Nyheter. 1963. "Finländerna hoppas på Stockholmsstudion." *Dagens Nyheter*, 4.4.1963, 19.

--- 1965. "Hommage à Picasso." *Dagens Nyheter*, 24.10.1965, 23.

--- 1965. "Konstsalongen Samlaren Picasso i går och i dag." *Dagens Nyheter*, 20.11.1965, 41.

--- 1966. "Det slutna rummet på museiexpo." *Dagens Nyheter*, 24.3.1966, 15.

--- 1969. "Rikskonserter i sommar: Musik från jätteballong strömmar över Östersund." *Dagens Nyheter*, 26.4.1969, 16.

--- 1969. "Nytt om nöjen – 30-tal." *Dagens Nyheter*, 12.6.1969, 22.

Eaton, Manford L. 1968. *Bio-potentials as Control Data for Spontaneous Music*. [S.l.]: Orcus.

ESS = Etelä-Suomen Sanomat. 1968. "Kritiikkiä M. A. Nummiselle." *Etelä-Suomen Sanomat*, 11.8.1968, 7.

--- 1971. "Tietokonesoitin kehitetty Suomessa." *Etelä-Suomen Sanomat*, 21.1.1971, 7.

Expressen 1966. "Då tog censuren låten…" *Expressen*, 24.10.1966, 5.

Gronow, Pekka. 1966. "M.A. ja minä." *Iskelmä*. 9/1966, 16–17 ja 47

Hbl.= Hufvudstadsbladet. 1964. "Elektrontonsättare utan konstambition." *Hufvudstadtsbladet*, 16.1.1964, 1, 11.

Heikinheimo, Seppo. 1962. "The University of Helsinki Electronic Music Studio." *World of Music* (4)3, June 1962, 56.

--- 1965. "Tyylinsä etsijöitä sekä nykymusiikin klassikoita." *Helsingin Sanomat*, 8.7.1965, 11.

--- 1967. "Tietokoneestako säveltäjien karsija." *Helsingin Sanomat*, 29.10.1967, 20.

--- 1972. "Tietokone orkesterin täydentäjänä Oulussa." *Helsingin Sanomat*, 20.10.1972, 24.

HS = Helsingin Sanomat. 1962. "Ylioppilasteatteri tarjoaa ekspressionismia ja runoa." *Helsingin Sanomat*, 9.10.1962, 21.

--- 1964. "Televisio tänään." *Helsingin Sanomat*, 22.3.1964, 15.

--- 1966. "Hei kaupunki – tervetuloa." *Helsingin Sanomat*, 4.5.1966, 16.

--- 1966. "Kirjallisuus ja taide – ensi-iltakalenteri." *Helsingin Sanomat*, 2.7.1966, 9.

--- 1968. "Liikettä, valoa ja sähkö Eino Ruutsalon näyttelyyn." *Helsingin Sanomat*, 17.1.1968, 17.

--- 1968. "Soulset, Numminen ja Muksut Sofiaan." *Helsingin Sanomat*, 14.7.1968, 15.

--- 1970. "[Wedding announcements]." *Helsingin Sanomat*, 15.5.1970, 13.

--- 1971. "Suomalainen teki sävellystietokoneen." [A Finn Designed a Composition Computer]. *Helsingin Sanomat*, 21.1.1971, 5.

--- 1971. "Ydinfyysikon sävelkone maailmanmarkkinoille." [The Nuclear Physicist's Tune Machine to the World Market]. *Helsingin Sanomat*, 21.1.1971, 13.

--- 1971. "tapahtuu tänään." *Helsingin Sanomat*, 26.5.1971, 18.

--- 1971. "Suomalainen yritys jo toiminnassa: Tv-kasetit käyttöön viimeistään v. 1978." *Helsingin sanomat*, 28.5.1971, 16.

--- 1971. "[Radio ja televisio]." *Helsingin Sanomat*, 20.7.1971, 25.

--- 1971. "Oulussa pidetään vakavasta musiikista." *Helsingin Sanomat*, 30.8.1971, 11.

Hämäläinen, Raimo. 1972, “Videopositiivi.” *Tekniikan Maailma*, 5/1972, 34–36.

[Juva, Mikko] 1972. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1971–1972*. Helsinki: Valtionneuvoston kirjapaino.

--- 1973. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1972–1973*. Helsinki: Valtionneuvoston kirjapaino.

J.V. 1960. “Norssit elektronimusiikin parissa.” *Uusi Suomi*, 18.3.1960, 18.

[Kivinen, Erkki] 1963. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1962–1963*. Helsinki: Valtionneuvoston kirjapaino.

--- 1965. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1964–1965*. Helsinki: Valtionneuvoston kirjapaino.

--- 1967. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1966–1967*. Helsinki: Valtionneuvoston kirjapaino.

--- 1968. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1967–1968*. Helsinki: Valtionneuvoston kirjapaino.

--- 1969. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1968–1969*. Helsinki: Valtionneuvoston kirjapaino.

--- 1970. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1969–1970*. Helsinki: Valtionneuvoston kirjapaino.

--- 1971. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1970–1971*. Helsinki: Valtionneuvoston kirjapaino.

Kujasalo, Kai and Fröberg, Per. 1971. “Syrjäyttääkö tietokone Kirkan?”. *Suosikki*, 6/1971, 1.6.1971, 67.

Kurenniemi, Erkki. 1971a. “Elektronisen musiikin instrumenteista.” *Musiikki*, 1(1), 37–41.

--- 1971b. “Message is massage.” *Taide*, 6/1971, 36–38.

--- (1972–1979?). *Programmable space*. [Thesis]. [Helsinki]: [Erkki Kurenniemi].

--- 1999. *Askeleen edellä: "Todellisuus on aina askeleen edellä mielikuvitusta": artikkeleita 1979–1999*. Helsinki: Edita: Kiasma, Nykytaiteen museo [jakaja].

--- 2004. “Oh, human fart.” *Framework*, 2/2004, 34–37.

--- 2015. “On Electronic Music Instruments.” [Elektronisen musiikin instrumenteista]. In J. Krysa, & J. Parikka (Eds.), *Writing and Unwriting (Media) Art History: Erkki Kurenniemi in 2048*. Cambridge: MIT Press. 255–260.

Leino, Eino. 1971. “Musiikkia uusilla uruilla: DIMI soi pian Suomen maailmankartalle.” *Apu*, 5.2.1971, 34–36.

Lindeman, Osmo. 1972. *Tietojenkäsittelyopin peruskurssi*. [Helsinki]: [Osmo Lindeman].

--- 1973. *Digitaalitekniikka*. [Helsinki]: [Osmo Lindeman].

--- 1974. *Elektronisen musiikin teknologia*. Helsinki: Sibelius-Akatemia.

--- 1976. *Johdatus musiikin teoriaan*. Helsinki: Otava.

--- 1980. *Elektroninen musiikki: Elektronisen äänisynteesin perusteet*. Helsingissä: Otava.

Linkomies, Edwin. 1962. *Kertomus Helsingin yliopiston toiminnasta lukuvuonna 1961–1962*. Helsinki: Valtionneuvoston kirjapaino.

Lundsten, Ralph. 2006. *En själens vagabond: en personlig levnadshistoria av och om en äventyrare i tid och rum*. Saltsjö-Boo: Andromeda.

--- 2014. *Cosmic Composer*. Saltsjö-Boo: Andromeda Music.

Länsi-Savo 1970. "Länsi-Savon Radio- ja TV-liite." *Länsi-Savo*, 17.10.1970, 10.

--- 1971. "Maailman ensimmäinen musiikkitietokone valmis." *Länsi-Savo*, 21.1.1971, 10.

Mallander, Jan Olof. 1970. "Itsestään selviä asioita." *Iiris*, 8/1970, 2–3.

Mangs, Runar 1965. "Till Picasso av Nilsson." *Dagens Nyheter*, 27.10.1965, 15.

Maunula, Leena. 1966. "Hei monimuotoinen kaupunki." *Helsingin Sanomat*, 15.5.1966, 22.

Nikkilä, Seppo 1993a. "Suomen ensimmäinen mikrotietokone." In *Mikrotietokone Suomessa 1973–1993*. Risto Linturi ja Martti Tala. (Eds.) Helsinki: Yritysmikrot Oy. 36–40.

--- 1993b. "Bugi hirtettiin kumilenkkiin." In *Mikrotietokone Suomessa 1973–1993*. Risto Linturi ja Martti Tala. (Eds.) Helsinki: Yritysmikrot Oy. 36–40.

Nilsson, Leo. 2014. *Musikens Väsen*. Stockholm: Themis.

Nordwall, Trygve. 1969. "Musikfestivalen i norr svårsmält för publiken." *Dagens Nyheter*, 3.7.1969, 16.

Nummi, Seppo. 1964. "Uusia akateemisia mestareita: Musiikkikilpailut päättyivät eilen." *Uusi Suomi*, 6.4.1964, 6.

Numminen, Mauri Antero. 1970. *Kauneimmat runot*. Helsinki: Kirjayhtymä Helsinki.

--- 1999. *Helsinkiin: Opiskelija Juho Niityn Sivistyshankkeet 1960–1964*. Espoo: Schildt.

--- 2020. *Kaukana väijyy ystäviä*. Helsinki: Docendo.

Olsson, Claes. 1971. "TV-kasetit – tajuntateollisuuden uusin ase." *Kansan Uutiset*, 1.5.1971.

Oramo, Ilkka. 1968. "Elektronifolklorea." *Helsingin Sanomat*, 29.9.1968, 19.

Pitkänen, Ilkka. 1970. "Nuorison taidetapahtuma: Vakka-Suomen Sähköheteeka ravisti unesta turkulaiset." *Helsingin Sanomat*, 31.10.1970, 29.

--- 1972. “Ihmelaatikko muuttaa muhinat musiikiksi.” *Iltasanomat*, 22.2.1972, 7.

Rautee, Risto. 1978. *Junavaa'an tietojenkäsittelyjärjestelmä* [Train scaling data processing system]. Teknillinen korkeakoulu, Otaniemi. http://doi.org/10.5281/zenodo.3592770.

Reijonen-Oibopuu, Tuuli. 1964. “Mustaa ja oranssia”. *Helsingin Sanomat*, 2.2.1964, 16.

Ruohomäki, Jukka. 1976. “Vaikutelmia Århusista: UNM-päivät 1976.” *Musiikki* 5(3): 43–49.

Salmenhaara, Erkki. 1964. “Erkki Kurenniemi och hans studio.” *Nutida Musik*, 5/1964, 55–56.

--- 1967. “Tietokonemusiikin ongelmia.” *Helsingin Sanomat*, 31.10.1967, 18.

--- 1968. *Vuosisatamme musiikki: 1900-luvun musiikin historia pääpiirteissään*. Helsinki: Otava.

--- 1969. “Elektrononstop.” *Helsingin Sanomat*, 19.11.1969, 16.

--- 1970. “Elektrotapahtuma.” *Helsingin Sanomat*, 19.11.1970, 19.

Saunio, Ilpo. 1963. “Keskikesän keskipiste – Jyväskylän kesä.” *Ylioppilaslehti*, 30.8.1963, 4.

Sirén, Pekka. 1976. “Kokeellisesta toiminnasta YLE:ssä.” In *Tehosteet ja ääni-ilmaisu*. R. Korpio (Ed.). Helsinki: Oy. Yleisradio Ab. 49–58.

Stockhausen, Karlheinz. 1958. ”Ajatuksia elektronisesta musiikista.” *Helsingin Sanomat*, 16.4.1958.

Stump. 1968a. Rajua undergroundia. *Stump*, 6/1968, 5.

--- 1968b. “Soulset soitteli kultaa Sofiassa: Mukana myös M.A. Numminen, Anki ja Muksut.” *Stump*, 9/1968, 19.

Tarkka, Pekka. 1971. “Kaksi mestaria.” *Helsingin Sanomat*, 28.11.1971, 22.

Tawaststjerna, Erik. 1967. The Department of Musicology annual allowance application in the UHMRL archive.

Tawaststjerna, Erik. 1970. The Department of Musicology annual allowance application in the UHMRL archive.

Tawaststjerna, Erik. 1971. The Department of Musicology annual allowance application in the UHMRL archive.

TV. 1968. “Dipoli: Vauhdikas tapahtuma saa yleisön mukaansa.” *Etelä-Suomen Sanomat*, 24.3.1968, 9.

Uusi Suomi. 1962. “Maeterlinckiä ja Tolleria Ylioppilasteatteriin.” *Uusi Suomi*, 10.10.1962, 17.

--- 1964. “Akateemiset kulttuurikilpailut tänä keväänä täydessä laajuudessa.” *Uusi Suomi*, 5.4.1964, 20.

--- 1971. “Uusi taiteilijaryhmä järjestää Elonkorjuujuhlan.” *Uusi Suomi*, 26.5.1971, 12.

Valkonen, Markku. 1972. “Dimensio Tampereella: Taiteen taikahattuja.” *Helsingin Sanomat*, 15.10.1972, 33.

Viikkosanomat. 1964. “Hän laulaa yksin.” *Viikkosanomat*, 10.4.1964, 47.

Virtaranta, Pertti, Huuhka, K., Koivisto, I., Polvinen, T., Tunkelo, E. & Wiio, O.A. 1973. *Tiedon värikäs maailma: nykyaikainen tietosanakirja*: osa 3: D–ETE. Helsinki: Uusi kirjakerho.

Wahlström, Erik. 1969. “Osmo Lindeman söker elektronmusikestetik.” *Hufvudstadsbladet*, 11.11.1969, 11.

Widding, Lars 1970. “Kärlekens ljuva musik.” *Expressen*, 8.8.1970, 13.

Zweigberck, Eva. 1966. “Hej stad.” *Dagens Nyheter*, 2.4.1966, 4.

Newspapers and magazines

Aftonbladet

Apu

Dagens Nyheter

Eksessi

Expressen

Etelä-Suomen Sanomat

Helsingin Sanomat

Hufvudstadtsbladet

Iiris

Iskelmä

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Photographs

Anon. [s.a.]. Photograph of Kurenniemi as an amateur radio operator. In The Finnish National Gallery/EKA.

Anon. [s.a.]. Photograph of Kurenniemi programming the DIMI-A. In The Finnish National Gallery/EKA.

Anon. [s.a.]. Photograph of The DIMI-S tested by two unidentified players. In The Finnish National Gallery/EKA.

Anon. [s.a.]. Photograph of The DIMI-S (Sexophone) presented by Ralph Lundsten in a Swedish Television documentary. In Ralph Lundsten archive.

Anon. [s.a.]. Photographs of The University Studio, 1971–1975. In The Finnish National Gallery/EKA.

Anon. [s.a.]. Photographs of The University Studio from 1976 to the late 1970s. In *Otavan iso musiikkitietosanakirja*.

Anon. [s.a.]. Photograph of Composer Ralph Lundsten in his Andromeda Studio. In *Otavan iso musiikkitietosanakirja*.

Anon. [s.a.]. Photograph of Ruohomäki programming the DIMI 6000 in the Yle Ratakatu Studio. In Pekka Sirén archive.

Anon. [s.a.]. Photograph of Pekka Sirén and Joe Davidow with the DIMI 6000. In Pekka Sirén archive.

Anon. [s.a.]. Photograph of the DIMI 6000. In *Otavan iso musiikkitietosanakirja*.

Anon. 1960. Photograph of Kurenniemi and his classmates on the loft of the school organ. In *Uusi Suomi* on March 18, 1960.

Anon. 1964. Photograph of M.A. Numminen and Kullervo Aura. In *Uusi Suomi* on April 5, 1964.

Anon. 1965. Photograph of Algorithmic music seminar with Ralph Lundsten, Leo Nillson and two identified persons in the Lehtikuva archive, ID: 2038894; Date Created: 19650707.

Anon. 1968. Photographs of *Sähkö-shokki-ilta* (Electric Shock Evening) at the Amos Anderson Art Museum, February 9, 1968. In The Amos Anderson Art Museum archive.

Anon. 1968. Photographs of The Andromatic in the exhibition *Den Immateriella Processen*. In The Finnish National Gallery/EKA.

Anon. 1968. Photograph of Ralph Lundsten in Samlaren Gallery in Ralph Lundsten archive. https://www.andromeda.se/wp-content/uploads/2012/10/anmdromaticljusterminal.jpg.

Anon. 1971. Photograph of The DIMI-O in the event featuring art group Elonkorjaajat. In The Finnish National Gallery/EKA.

Anon. 1972. Photograph of the DIMI-S in Ralph Lundsten archive. https://www.andromeda.se/wp-content/uploads/2012/10/dimi-s.jpg.

Anon. 1972. Photographs of Erkki Kurenniemi and the DIMI-O in the Lehtikuva archive IDs: 2125578, 2125579, 1316483; Date Created: 19720124.

Anon. 1975. Photograph of Lindeman's home studio setup in 1975. In *Otavan iso musiikkitietosanakirja*.

Ekholm, H. 1965. Photograph of Erkki Kurenniemi in the Lehtikuva archive, ID: 1316442; Date created: 19650323.

Hakli, K. 1959. Heimolan talon elokuvateatterit Aloha ja Arita. https://www.finna.fi/Record/kansa_ah.M011-1388008?.

Hakli, K. 1969. Hallituskatu 15 (=Yliopistonkatu 5), Heimolan talo. https://hkm.finna.fi/Record/hkm.HKMS000005%3Akm003w7c.

Haraste, P. 1968. Photograph of M.A. Numminen in the Lehtikuva archive ID: 1928201; Date Created: 19680715.

Jenytin, P. 1962. Photograph of Erik Tawaststjerna in the Lehtikuva archive, ID: 6667509; Date created: 19620901.

Kurenniemi, E. 1968. A series of photographs of the Andromatic at the Andromeda studio in Kurenniemi's collection in FNG/EKA.

--- 1974. A series of photographs in the Yle Liisankatu Studio on February 27, 1974 in Kurenniemi's collection in FNG/EKA.

Lindeman. S. 1972. Photograph of Composer Osmo Lindeman in his home studio in 1972. In Osmo Lindeman archive.

Messo, P. 1970. Photograph of the DIMI-A and Sähkökvartetti in the Lehtikuva archive ID: 33197848; Date Created: 19701117.

Oksanen, M. 1968. Photograph of Sähköshokki-ilta with Erkki Kurenniemi, Kalevi Seilonen and Cleas Andersson in the Lehtikuva archive, ID: 22215978; Date Created: 19680209.

Saves, M. 1971. Photographs of Erkki Kurenniemi and Jukka Ruohomäki in the Lehtikuva archive ID: 1316478, 1260078, 1260076; Date Created: 19710120.

Tapola, M. 1964. Photograph of M.A. Numminen in the Lehtikuva archive ID: 4160308; Date Created: [19640404].

Research data publications

Lindeman, Osmo, & Lindeman, S., & Ojanen, M. (2020). *The Scrapbook of Osmo Lindeman: catalogued and annotated contents with sample pictures* [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3886432.

Ojanen, Mikko. 2018. *Arrangement of J.S. Bach's Invention No. 13 in A minor (BWV784) for the DIMI-A synthesizer by Erkki Kurenniemi (1970): An annotated video of the master tape*. Zenodo. http://doi.org/10.5281/zenodo.1469722.

--- 2018. *Templates for agreements and contracts on research data and materials*. Zenodo. https://doi.org/10.5281/zenodo.846985.

--- 2019. *Appearances of Erkki Kurenniemi's Electronic Musical Instruments* (Version 20191130) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.842854.

--- 2019. *The development of Digelius Electronics Finland (DEF) in the documentary evidence* (Version 20191225_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3592770.

--- 2019. *Preliminary metadata for the UHMRL digital tape archive pilot* (Version 20191223_01) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.3591336.

--- 2019. *The User Interface and Functionality Charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* [Data set]. Zenodo. https://doi.org/10.5281/zenodo.3596466.

--- 2020. *Analyses of the works of art and events related to Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* https://doi.org/10.5281/zenodo.2092577.

--- 2020. *The Photo Set of the Master Tape of Erkki Kurenniemi's On-Off (1963)* (Version 20200108_01). Zenodo. http://doi.org/10.5281/zenodo.3601403.

--- 2020. *The User Interface and Functionality Charts of Erkki Kurenniemi's Electronic Musical Instruments (EKIS)* (Version Version 2: 20200101) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.2089416.

Sound recordings

Carlos, W. 1968. *Switched-On Bach*. (Columbia Masterworks – MS 7194). https://www.discogs.com/Walter-Carlos-Switched-On-Bach/release/1308287.

Ciani, S. 2016. *Buchla Concerts 1975*. (Finders Keepers Records – FKR082LP). https://www.discogs.com/Suzanne-Ciani-Buchla-Concerts-1975/release/8439470.

Koivistoinen, E. 1971. *Muusa ja Ruusa* (WSOY – WS 8) https://www.discogs.com/Eero-Koivistoinen-Muusa-Ja-Ruusa/release/2450473.

Kurenniemi, E. 2002. *Äänityksiä/Recordings 1963–1973*. (Love Records – LXCD 637). https://www.discogs.com/Erkki-Kurenniemi-%C3%84%C3%A4nityksi%C3%A4-Recordings-1963-1973/release/221581.

--- 2012. *Rules*. (Full Contact Records – KRYPT-022). https://www.discogs.com/Erkki-Kurenniemi-Rules/release/3791751.

--- 2012. *Music for the film Hyppy*. In *Rules*. (Full Contact Records – KRYPT-022). https://soundcloud.com/ektrorecords/erkki-kurenniemi-music-for-the.

Lundsten, R. & Nilsson. L. 1966. *Elektronmusikstudion Dokumentation 1*. (Sveriges Radio – LPD 1). https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Elektronmusikstudion-Dokumentation-1/release/938156.

--- 1967. *MUMS: Musik Under Millioner Stjärnor*. (Sveriges Radio – RELP 5023). https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-MUMS-Musik-Under-Millioner-Stj%C3%A4rnor/release/1321092.

--- 1968. *Elektronisk Musik*. (His Master's Voice –CSDS 1085). https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Elektronisk-Musik/release/907465.

--- 1968. *Feel it*. (Andromeda – A2). https://www.discogs.com/Ralph-Lundsten-And-Leo-Nilsson-Feel-It/release/2473419.

--- 1969. *Feel it. Exhibition Edition*. (Andromeda – A2). https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Feel-It-Exhibition-Edition-/release/10416668.

--- 1969. *Tellus / Fågel Blå*. (Telestar – TRS 11066). https://www.discogs.com/Ralph-Lundsten-Leo-Nilson-Tellus-F%C3%A5gel-Bl%C3%A5/release/2215498.

Nilsson, L. 1964. *Skorpionen / Copa De Poma*. ([Konstsalongen Samlaren]). https://www.discogs.com/Leo-Nilson-Skorpionen-Copa-De-Poma/release/11323683#images/31900490.

Numminen, M.A. 1964. Background tape for *Oigu-S*. In *More Arctic Hysteria / Son Of Arctic Hysteria: The Later Years Of Early Finnish Avant-Garde* (Love Records – LXCD 647) https://www.discogs.com/Various-More-Arctic-Hysteria-Son-Of-Arctic-Hysteria-The-Later-Years-Of-Early-Finnish-Avant-Garde/release/600283.

--- 1970. *Taisteluni*. (Love Records – LXLP 501). https://www.discogs.com/MA-Numminen-Ja-Viisi-Vierasta-Miest%C3%A4-Taisteluni/release/714591.

Salmenhaara, E. 1967. *Information Explosion*. (Love Records – LREP 103). https://www.discogs.com/Erkki-Salmenhaara-Information-Explosion/release/8819351.

Various. 1968. *Perspectives '68 – Music In Finland*. (Love Records – LRLP 4). https://www.discogs.com/Various-Perspectives-68-Music-In-Finland/release/1389437.

--- 1978. *Suomalaista Elektroakustista Musiikkia – Finnish Electro-Acoustic Music*. (Fennica Nova – FENO 5). https://www.discogs.com/Various-Suomalaista-Elektroakustista-Musiikkia-Finnish-Electro-Acoustic-Music/release/1469987.

--- 1982. *Musica Nova Academiae. Sibelius-Akatemia 1882 – 1982*. (SALP 1). https://www.discogs.com/Various-Musica-Nova-Academiae-Sibelius-Akatemia-1882-1982/release/6521662.

Websites

120 years of electronic music. http://120years.net/.

Avaruusromua: https://yle.fi/aihe/ohjelma/avaruusromua.

Andrew Bentley's Sound Cloud: https://soundcloud.com/andrew-bentley-804731324.

Electronic Musical Instruments by Erkki Kurenniemi website: http://ekis.helsinki.fi.

Electronic Musical Instruments by Erkki Kurenniemi, Zenodo community: https://zenodo.org/communities/electronic-musical-instruments-by-kurenniemi/.

Elonet: https://elonet.finna.fi/.

Finna.fi: https://www.finna.fi/Content/about.

Finnish Electroacoutic Research Sources: http://finears.helsinki.fi.

IMDB: https://www.imdb.com/.

Kansallinen audiovisuaalinen instituutti: Kavi (National Audiovisual Institute): https://kavi.fi/.

Kansallisbiografia (National Biography of Finland): https://kansallisbiografia.fi/.

Kansalliskirjasto (National Library of Finland's digital archive): https://digi.kansalliskirjasto.fi/.

Lehtikuva: http://kuvakauppa.lehtikuva.fi/edoris?tem=www_e.

Leo Nilsson's Sound Cloud: https://soundcloud.com/user-745910767.

Music Finland: https://musicfinland.com.

NIMiMS: Network for the inclusion of music in music studies: http://nimims.net/.

Phinnweb: http://www.phinnweb.org/.

Radioamatööritoiminnan kutsumerkit ja yhteisöt Suomessa: https://fi.wikipedia.org/wiki/Radioamat%C3%B6%C3%B6ritoiminnan_kutsumerkit_ja_yhteis%C3%B6t_Suomessa.

Rahanarvolaskuri (Money Value Converter): http://apps.rahamuseo.fi/rahanarvolaskin#ENG.

Otto Romanowski's Sound Cloud: https://soundcloud.com/oromanow.

S-HIP – Society for Historical Informed Performance: https://sohipboston.squarespace.com/what-is-hip/.

Scenknostmuseet, teater, musik, dans, kultur (the Swedish Museum of Performing Arts) https://scenkonstmuseet.se/.

Vanhat Norssit semanttisessa webissä: http://www.norssit.fi/semweb/.

WikiChip, MCS-8: https://en.wikichip.org/wiki/intel/mcs-8.

Ylioppilasteatteri (Helsinki Student Theater): https://ylioppilasteatteri.fi/in-english/.

Äänenlumo.fi: www.aanenlumo.fi.

Research literature

Adams, Norman. 2006. Visualization of Musical Signals. In M. Simoni (Ed.), *Analytical Methods of Electroacoustic Music*. New York: Routledge. 13–28.

Adorno, Theodor W. 2006. *Esteettinen Teoria*. Tampere: Vastapaino.

Akrich, Madeleine. 1992. The De-Scription of Technical Objects. In W. Bijker, & J. Law (Eds.), *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, Mass.: MIT press. 205–224.

Anttonen, Erkki. 1995. *Performance, Aktio, Happening: Jälkiä katoavasta taiteesta*. Helsinki: Helsingin yliopiston taidehistorian laitos.

Arrasvuori, Juha. 2006. *Playing and Making Music: Exploring the Similarities between Video Games and Music-Making Software*. Tampere: Tampere University Press.

Ashby, Arved. 2010. *Absolute Music, Mechanical Reproduction*. Berkeley: University of California Press.

Baer, C. T. 2011. From “Home Sweet Home" to "Karn Evil 9”: Hagley documents the origins of the synthesizer. https://www.hagley.org/librarynews/home-sweet-home-karn-evil-9-hagley-documents-origins-synthesizer.

Ballantine, Christopher. 1977. Towards an aesthetic of experimental music. *The Musical Quarterly*, 63(2), 224–246.

Bent, Ian. 1987. *Analysis*. London: Macmillan Press, Music Division.

Bernstein, David W. 2008. *The San Francisco Tape Music Center: 1960s Counterculture and the Avant-Garde*. Berkeley: University of California Press.

Bijker, Wiebe. 1995. *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge: MIT.

Bijker, Wiebe E., & Law, J. (Eds.). 1992. *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, Mass.: MIT Press.

Bijker, Wiebe, Hughes, T., & Pinch, T. 2012a. Introduction. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Anniversary Edition*. Cambridge. Cambridge: The MIT Press. 3–10.

--- 2012b. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Anniversary edition Cambridge: The MIT press.

Bijker, Wiebe, & Pinch, T. 2012. Preface to the Anniversary Edition. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Anniversary Edition*. Cambridge: The MIT press. xi–xxxiv.

Birnbaum, David, Fiebrink, R., Malloch, J., & Wanderley, M. M. 2005. Towards a Dimension Space for Musical Devices. *Proceedings of the 2005 Conference on New Interfaces for Musical Expression*. Singapore: National University of Singapore. 192–195.

Borgmann, Albert. 1984. *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: Chicago University Press.

Born, Georgina. 1995. *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-Garde*. Berkeley: University of California Press.

Broman, Per Olov. 2007. *Kort Historik Över Framtidens Musik: Elektronmusiken Och Framtidstanken i Svenskt 1950- Och 60-Tal*. Stockholm: Gidlund.

Burke, Peter. 1991a. History of Events and the Revival of Narrative. In P. Burke (Ed.), *New Perspectives on Historical Writing*. Cambridge: Polity Press. 233–248.

--- 1991b. Overture: The New History, its Past and its Future. In P. Burke (Ed.), *New Perspectives on Historical Writing*. Cambridge: Polity Press. 1–23.

Böhme-Mehner, Tatjana. 2011. Does the GDR have its own electroacoustic sound? *Contemporary Music Review*, 30(1), 5–13.

Callon, Michel. 1980. The state and technical innovation: A case study of the electrical vehicle in France. *Research Policy*, 9(4), 358–376. https://doi.org/10.1016/0048-7333(80)90032-3.

--- 2012. Society in the Making: The Study of Technology as a Tool for Sociological Analysis. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge: MIT Press. 77–97.

Camilleri, Lelio, & Smalley, D. 1998. The analysis of electroacoustic music: Introduction. *Journal of New Music Research*, 27(1), 3–12.

Carr, Edward Hallett. 1986. *What is History?* 2nd ed. London: Macmillan.

Cascone, Kim. 2000. The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music. *Computer Music Journal,* 24(4), 12–18.

Chadabe, Joel. 1997. *Electric Sound: The Past and Promise of Electronic Music*. Upper Saddle River, New Jersey: Prentice-Hall.

--- 2005. Writing History and Preservation. *EMS Proceedings and Other Publications: EMS05 – Sound in Multimedia Contexts*, Montréal.

Cogan, Robert. 1984. *New Images of Musical Sound*. Cambridge (Mass.): Harvard University Press.

Collins, Nick, & d'Escriván, J. (Eds.). 2007. *The Cambridge Companion to Electronic Music*. Cambridge: Cambridge University Press.

Collins, Nick, Schedel, M., & Wilson, S. 2013. *Electronic Music*. Cambridge: Cambridge University Press.

Collins, Nicolas. 2006. *Handmade Electronic Music: The Art of Hardware Hacking*. New York and London: Routledge.

Crab, S. 2015. "'DIMI' & Helsinki Electronic Music Studio, Erkki Kurenniemi. Finland, 1961." In *120 years of electronic music*. http://120years.net/dimi-helsinki-electronic-music-studioerkki-kurenniemifinland1961-2/

Dahlhaus, Carl. 1983. *Foundations of Music History*. Cambridge: Cambridge University Press.

--- 1989. *The Idea of Absolute Music*. Chicago: University of Chicago Press.

Delalande, François. 1998. Music analysis and reception behaviors: Sommeil by Pierre Henry. *Journal of New Music Research*, 27(1), 13–66.

Demers, Joanna Teresa. 2010. *Listening through the Noise: The Aesthetics of Experimental Electronic Music*. New York: Oxford University Press.

Denzin, Norman K. 1970a. *The Research Act: A Theoretical Introduction to Sociological Methods*. Chicago: Aldine.

--- 1970b. *Sociological Methods: A Sourcebook*. London: Butterworths.

Doornbusch, Paul. 2017. Early computer music experiments in Australia and England. *Organised Sound*, 22(2), 297–307.

Dunsby, Jonathan. 1983. Music and semiotics: The Nattiez phase. *The Musical Quarterly*, 69(1), 27–43.

Eerikäinen, Hannu. 2007. Videotaide Suomessa: Taiteen laidalla, eturintamassa vai ei-kenenkään maalla? In K. Väkiparta (Ed.), *Sähkömetsä: Videotaiteen ja kokeellisen elokuvan historiaa Suomessa 1933–1998*. 82–137.

Elster, Jon. 1983. *Explaining Technical Change: A Case Study in the Philosophy of Science*. Cambridge: Cambridge University Press.

Emmerson, Simon. 1982. *Analysis and the composition of electroacoustic music*. Authorized facsimile, UMI Dissertation Information Service.

Emmerson, Simon. 1986. The Relation of Language to Materials. In S. Emmerson (Ed.), *The Language of Electroacoustic Music*. Basingstoke: Macmillan. 17–39.

Emmerson, Simon, & Landy, L. 2016. The Analysis of Electroacoustic Music: The Differing Needs of its Genres and Categories. In S. Emmerson & L. Landy (Eds), *Expanding the Horizon of Electroacoustic Music Analysis*. Cambridge: Cambridge University Press. 8–27.

Emmerson, Simon, & Smalley, D. 2001. Electro-Acoustic Music. *Grove Music Online*. Oxford: Oxford University Press. https://doi.org/10.1093/gmo/9781561592630.article.08695

Ensmenger, Nathan. 2010. *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise*. Cambridge, Mass.: MIT Press.

Essl, Karlheinz. 2007. Algorithmic Composition. In N. Collins, & J. d'Escriván (Eds.), *The Cambridge Companion to Electronic Music*. Cambridge University Press. 106–125.

Fagerberg, Jan. 2006. Innovation: A Guide to the Literature. In J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press. 1–26.

Gaskell, Ivan. 2001. Visual History. In P. Burke (Ed.), *New Perspectives on Historical Writing*. 2nd ed. Cambridge: Polity. 187–217.

Geertz, Clifford. 1973. *The Interpretation of Cultures: Selected Essays*. New York: Basic Books.

Ginzburg, Carlo. 1989. *Clues, Myths, and the Historical Method*. [Miti emblemi spie: morfologia e storia] (J. Tedeschi, A. C. Tedeschi Trans.). Baltimore: Johns Hopkins University Press.

--- 1993. Microhistory: Two or three things that I know about it. *Critical Inquiry*, 20(1), 10–35.

--- 2012. Our Word, and theirs: A Reflection on the Historian's Craft, Today. In S. Fellman, & M. Rahikainen (Eds.), *Historical Knowledge: In Quest of Theory, Method and Evidence*. Newcastle upon Tyne: Cambridge Scholars. 97–120.

Glinsky, Albert. 2000. *Theremin: Ether music and espionage*. Urbana and Chicago: University of Illinois Press.

Gloag, Kenneth. 2015. "A Thing of the Past": Canon Formation and the Postmodern Condition. In V. Kurkela, & M. Mantere (Eds.*), Critical Music Historiography: Probing Canons, Ideologies and Institutions*. Farnham, Surrey: Ashgate. 227–237.

Godin, Benoît. 2006. The linear model of innovation: The historical construction of an analytical framework. *Science, Technology, & Human Values*, 31(6), 639–667.

Goehr, Lydia. 1992. Writing music history. *History and Theory*, 31(2), 182–199.

--- 2007. *The Imaginary Museum of Musical Works: An Essay in the Philosophy of Music*. Rev. ed. Oxford: Oxford University Press.

Goldberg, RoseLee. 1979. *Performance Art: From Futurism to the Present*. London: New York: Thames and Hudson.

Groth, Sanne Krogh. 2014. *Politics and Aesthetics in Electronic Music: A Study of EMS – Elektronmusikstudion Stockholm, 1964–1979*. Berlin: Kehrer.

Hamilton, Andy. 2007. *Aesthetics and Music*. London; New York: Continuum.

Haring, Kristen. 2007. *Ham Radio's Technical Culture*. Cambridge, Mass.: MIT Press.

Hatten, Robert S. 1992. Kofi Agawu. Playing with signs: A semiotic interpretation of classic music. Princeton: Princeton university press, 1991 and

Jean-Jacques Nattiez. Music and discourse: Toward a semiology of music. Translated by Carolyn Abbate. (Translation and abridgment of musicologie genéralé et sémiologie [Paris: Christian bourgois, 1987].) Princeton: Princeton university press, 1990. *Music Theory Spectrum*, 14(1), 88–98. https://doi.org/10.2307/746084.

Hattwick, I., & Wanderley, M. M. A 2012. Dimension Space for Evaluating Collaborative Musical Performance Systems. *New Interfaces for Musical Expression*.

Headland, Thomas L. 1990. Introduction: A Dialogue between Kenneth Pike and Marvin Harris on Emics and Etics. In M. Harris, T. L. Headland & K. L. Pike (Eds.), *Frontiers of Anthropology*. Newbury Park, Calif.: Sage.

Heidegger, Martin. 1953. Tekniikan kysyminen [Die Frage Nach Der Technik]. *Niin & Näin*, 2(94), 31–40.

Heiniö, Mikko. 1986. *12-säveltekniikan aika: Dodekafonian ja sarjallisuuden reseptio ja Suomen luova säveltaide 1950-luvulta 1960-luvun puoliväliin*. Helsinki: Suomen musiikkitieteellinen seura.

--- 1988. *Lastenkamarikonserteista pluralismiin: Postmoderneja piirteitä uudessa suomalaisessa musiikissa*. Helsinki: Suomen musiikkitieteellinen seura.

--- 1995. *Suomen musiikin historia 4: Aikamme musiikki 1945–1993*. Porvoo: WSOY.

Henriksson, Juha. 2016. [Sleeve Notes]. Eero Koivistoinen: *Muusa ja Ruusa*. (Svart Records, SRE049).

Hobsbawm, Eric. 1980. The revival of narrative: Some comments. *Past & Present*, (86), 3–8.

--- 1998. *On History*. London: Abacus.

Holmes, Thom. 2012. *Electronic and Experimental Music: Technology, Music, and Culture*. 4th New York: Taylor & Francis.

Home, Marko. 2013. Uuden tuulen havinaa ilmassa: Sähkö-shokki-ilta 1968. [New Swish in the Air: Electric-Shock-Evening 1968] *Musiikin Suunta*, 35(3), 17–23.

--- [forthcoming]. *”Pysähtymisessä vaanii kuolema!” – Eino Ruutsalon kokeellinen 1960-luku sekä siihen johtanut kehity*. [Working title of the fortcoming doctoral dissertation]. [s.l.]: [s.n.].

Hughes, Thomas. 1986. The seamless web: Technology, science, etcetera, etcetera. *Social Studies of Science*, 16(2), 281–292.

--- 1994. Technological Momentum. In M. R. Smith, & L. Marx (Eds.), *Does Technology Drive History?: The Dilemma of Technological Determinism*. Cambridge: The MIT Press. 101–113.

--- 2012. The Evolution of Large Technological Systems. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Anniversary Edition Cambridge: The MIT press. 45–76.

Hultberg, Teddy. 1994. *Fylkingen: Ny Musik & Intermediakonst*: Rikt Illustrerad Historieskrivning & Diskussion För Radikal & Experimentell Konst 1933–1993. Stockholm: Fylkingen.

Huttunen, Matti. 1993. *Modernin musiikinhistoriankirjoituksen synty Suomessa: musiikkikäsitykset tutkimuksen uranuurtajien tuotannossa*. Helsinki: Suomen musiikkitieteellinen seura.

--- 1995. The "Canon" of Music History and the Music of a Small Nation. In U. Lippus (Ed.), *Music History Writing and National Culture: Proceedings of a Seminar, Tallinn, December 1–3, 1995*. Tallinn: Eesti Keele Institut. 20–30.

Hvidlykke, John Alex. 2013. Erkki Kurenniemi: Pioneer of digital synthesis. *Sound on Sound*, September 2013 Retrieved from https://www.soundonsound.com/people/pioneer-digital-synthesis

Jensen, K.B. 2016. Intermediality. In K.B. Jensen, E.W. Rothenbuhler, J.D. Pooley and R.T. Craig (Eds), *The International Encyclopedia of Communication Theory and Philosophy*. https://doi.org/10.1002/9781118766804.wbiect170

Jeppesen, Knud, & Lindeman, O. 1972. *Kontrapunkti: Klassisen vokaalipolyfonian oppikirja*. Helsinki: Musiikki Fazer.

Jordà, Sergi. 2004. Instruments and players: Some thoughts on digital lutherie. *Journal of New Music Research*, 33(3), 321–341.

Juva, Anu. 2008. *"Hollywood-syndromi", jazzia ja dodekafoniaa: elokuvamusiikin funktioanalyysi neljässä 1950- ja 1960-luvun vaihteen suomalaisessa elokuvassa*. Åbo: Åbo akademis förlag = Åbo Akademi University Press.

Jylhä, Minna. 2002. Dimensio 1972–2002. In O. Kantokorpi (Ed.), *Dimensio 30: Dimension Vuodet 1972–2002*. Helsinki: Like.

Kahn, David. 2001. *Noise, Water, Meat: A History of Sound in the Arts*. Cambridge, MA: MIT Press.

Kane, Brian. 2014. *Sound Unseen: Acousmatic Sound in Theory and Practice*. New York: Oxford University Press.

Kantokorpi, Otso (Ed.). 2002. *Dimensio 30. Dimension Vuodet 1972–2002*. Helsinki: Like.

Karjalainen, Toni-Matti, & Kärki, K. (Eds.) 2020. *Made in Finland: Studies in Popular Music*. New York: Routledge.

Katz, Mark. 2010. *Capturing Sound: How Technology has Changed Music*. 2nd and revised edition Berkeley: University of California Press.

--- 2012. *Groove Music: The Art and Culture of the Hip-Hop DJ*. Oxford University Press.

Korhonen, Kimmo. 2002. New Music of Finland. In J. D. White & J. Christensen (Eds.) *New Music of the Nordic Countries*. [Hillsdale, NY]: Pendragon Press. 121–286.

Krysa, Joasia, & Parikka, J. (Eds.). 2015. *Writing and Unwriting (Media) Art History: Erkki Kurenniemi in 2048*. Cambridge, Mass: MIT Press.

Kuljuntausta, Petri. 2002. *On/Off: Eetteriäänistä sähkömusiikkiin*. Helsinki: Like.

--- 2008. *First Wave: A Microhistory of Early Finnish Electronic Music*. Helsinki: Like.

--- 2020. The Hunters of New Sounds: Early Electronic Music Instruments and the Dawn of DIY Culture. In T.-M. Karjalainen & K. Kärki (Eds.) *Made in Finland: Studies in Popular Music*. New York: Routledge. 127–140.

Kurkela, Vesa, & Väkevä, L. 2009. Introduction. In V. Kurkela, & L. Väkevä (Eds.), *De-Canonizing Music History*. Newcastle upon Tyne: Cambridge Scholars Publishing. vii–xiii.

Laiho, Timo. 1982. *Suomen musiikkinuorison "Lastenkamarikonsertit" ja niihin liittynyt lehdistöpolemiikki 1962–64*. [S.l.]: [s.n.].

Laine, Pauli. 1984. *Katsaus Suomen elektronimusiikin vaiheisiin*.

Landy, Leigh. 1994. The "something to hold on to factor" in timbral composition. *Contemporary Music Review*, 10(2), 49–60.

--- 1999. Reviewing the musicology of electroacoustic music: A plea for greater triangulation. *Organised Sound*, 4(1), 61–70.

--- 2007. *Understanding the Art of Sound Organization*. Cambridge, Mass: MIT Press.

Lassfolk, K. 2012. Erkki Kurenniemen elektroakustisten sävellysten sointimaailma. *Suomen Musiikkitiede 100 Vuotta: Juhlasymposiumin Satoa*, Helsinki. 58–65.

--- 2013a. The Electronic Music of Erkki Kurenniemi. In M. Mellais (Ed.), *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery. 74–98.

--- 2013b. Fourier-muunnos ja spektrianalyysikuvaajien tulkinta musiikintutkimuksessa, osa 1. *Musiikin Suunta*, 35(1), 55–62.

Lassfolk, K., Suominen, J., & Ojanen, M. 2014. DIMI-6000: An Early Musical Microcomputer by Erkki Kurenniemi. *Proceedings of the 2014 ICMC Conference, Athens*, 40 1538–1541.

--- 2015. Interaction of Music and Technology: The Music and Musical Instruments of Erkki Kurenniemi. In J. Krysa, & J. Parikka (Eds.), *Writing and Unwriting (Media) Art History: Erkki Kurenniemi in 2048*. Cambridge: MIT Press. 261–277.

Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers through Society*. Milton Keynes: Open University Press.

Law, John. 2012. Technology and Heterogeneous Engineering: The Case of Portuguese Expansion. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge: MIT Press. 105–128.

Lemola, Tarmo. 2000a. Esipuhe. In T. Lemola (Ed.), *Näkökulmia teknologiaan*. Helsinki: Gaudeamus. 9–15.

--- 2000b. *Näkökulmia teknologiaan*. Helsinki: Gaudeamus.

Leskinen, Jaakko. 2000. Michel Callon Ja Sosiologian Materialisointi. In T. Lemola (Ed.), *Näkökulmia teknologiaan*. Helsinki: Gaudeamus. 176–192.

Levi, Giovanni. 1991. On Microhistory. In P. Burke (Ed.), *New Perspectives on Historical Writing*. Cambridge: Polity Press. 93–113.

--- 2012. Microhistory and the Recovery of Complexity. In S. Fellman, & M. Rahikainen (Eds.), *Historical Knowledge: In Quest of Theory, Method and Evidence*. Newcastle upon Tyne: Cambridge Scholars. 121–132.

Lindfors, Jukka. 2016. *Eteenpäin! 1966–1970* [Sleeve Note for a 6 LP Box-set]. Turku: Svart Records.

Lindfors, Jukka, & Salo, M. 1988. *Ensimmäinen aalto: Helsingin underground 1967–1970*. Helsinki: Odessa.

Lång, Peter. 1990. *Den tidigaste elektronmusiken i Finland*. Master's thesis, Åbo akademi, Musikvetenskapliga institution.

Magnusson, Thor. 2009. *Epistemic Tools: The Phenomenology of Digital Musical Instruments*. University of Sussex.

--- 2010. An Epistemic Dimension Space for Musical Devices. *Proceedings of the 2010 Conference on New Interfaces for Musical Expression*, 43–46.

Manning, Peter. 2013. *Electronic and Computer Music*. 4th edition. Oxford: Oxford University Press.

Mantere, Markus, & Kurkela, V. 2015. Introduction. In V. Kurkela, & M. Mantere (Eds.), *Critical Music Historiography: Probing Canons, Ideologies and Institutions*. Farnham, Surrey: Ashgate. 1–13.

Marx, Leo, & Smith, M. R. 1994. Introduction. In L. Marx, & M. R. Smith (Eds.), *Does Technology Drive History?: The Dilemma of Technological Determinism*. Cambridge (Mass.): MIT Press. ix–xv.

Mathews, M. V. 1963. The digital computer as a musical instrument. *Science*, 142(3592), 553–557. doi:10.1126/science.142.3592.553

McLuhan, Marshall. 1964. *Understanding Media: The Extensions of Man*. New York: McGraw-Hill.

McMaster, Tom, Vidgen, R. T., & Wastell, D. G. 1997. Technology Transfer: Diffusion Or Translation? In T. McMaster, E. Mumford, E. B. Swanson, B. Warboys & D. Wastell (Eds.), *Facilitating Technology Transfer through Partnership: Learning from Practice and Research*. Boston, MA: Springer.

Megill, Allan. 2007. *Historical Knowledge, Historical Error: A Contemporary Guide to Practice*. Chicago, Ill: University of Chicago Press.

Mellais, Maritta. 2013[2010]. Erkki Kurenniemen arkisto. In M. Mellais (Ed.), *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery, Central Art Archives. http://www.lahteilla.fi/kurenniemi/fi/erkki-kurenniemen-arkisto

Mellais, Maritta (Ed.). 2013. *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery.

Merriam-Webster. 2019. A keyword entry Agent. *Dictionary by Merriam-Webster*. https://www.merriam-webster.com/dictionary/agent (Retrieved on September 17, 2019).

Moisala, Pirkko, & Seye, E. 2013. Musiikintutkija ihmisten keskellä: Etnomusikologinen kenttätyö. In P. Moisala, & E. Seye (Eds.), *Musiikki kulttuurina*. Helsinki: Suomen etnomusikologinen seura. 29–55.

Molino, Jean. 1990. Musical fact and the semiology of music. *Music Analysis*, 9(2), 105–156.

Monroe, Alexei. 2003. Ice on the circuits/coldness as crisis: The re-subordination of laptop sound. *Contemporary Music Review*, 22(4), 35–43.

Muikku, Jari. 2001. *Musiikkia kaikkiruokaisille: Suomalaisen populaarimusiikin äänitetuotanto 1945–1990*. Helsinki: Gaudeamus.

Mumma, Gordon, Fillion, M., & Wolff, C. 2015. *Cybersonic Arts: Adventures in American New Music*. Urbana, Illinois: University of Illinois Press.

Nattiez, Jean-Jacques. 1975. *Fondements D'Une Sémiologie De La Musique*. Paris: Union Générale d'Éditions.

--- 1989. Reflections on the development of semiology in music. *Music Analysis*, 8(1), 21–75.

--- 1990. *Music and Discourse: Toward a Semiology of Music*. Princeton (N.J.): Princeton University Press.

Niebur, Louis. 2010. *Special Sound: The Creation and Legacy of the BBC Radiophonic Workshop*. Oxford: Oxford University Press.

Niemelä, Riikka. 2019. *Performatiiviset jäljet. Teos ja tallenne esityslähtöisessä mediataiteessa*. Turku: Turun yliopisto.

Niiniluoto, Ilkka. 2000. Tekniikan filosofia. In T. Lemola (Ed.), *Näkökulmia teknologiaan*. Helsinki: Gaudeamus. 16–35.

Nikki, Tarja. 1993. *Dualistisen sointuteorian tarkastelua kuulohavainnon pohjalta: Erityistapauksina Jouko Tolosen ja Erkki Kurenniemen teoriat*. Helsinki: Tarja Nikki.

O'Modhrain, Sile. 2011. A framework for the evaluation of digital musical instruments. *Computer Music Journal*, 35(1), 28–42.

Ojanen, Mikko. 2013. Erkki Kurenniemi's Electronic Music Studio. In M. Mellais (Ed.), *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery, Central Art Archives. 99–128.

--- 2014a. Electroacoustic concert and happening performances of the '60s and early '70s in Finland. *Proceedings of the Electroacoustic Music Stud-*

ies Network Conference (EMS14): Electroacoustic Music Beyond Concert Performance, Berlin.

--- 2014b. Jukka Ruohomäen ensimmäisen sävellyskauden elektroakustinen musiikki. *Musiikki*, 44(1–2), 146–183.

--- 2015. Mastering Kurenniemi's Rules (2012): The role of the audio engineer in the mastering process. *Journal on the Art of Record Production*, (10)

--- [forthcoming]. Kurenniemi, Erkki. In *Kansallisbiografia-verkkojulkaisu*. Helsinki: Suomalaisen Kirjallisuuden Seura, 1997– https://kansallisbiografia.fi/

Ojanen, Mikko, & Lassfolk, K. 2012. Material tape as a piece of art: case studies of an inconstant work-concept in Erkki Kurenniemi's Electroacoustic Music. *Proceedings of the Electroacoustic Music Studies Network Conference (EMS12): Meaning and Meaningfulness in Electroacoustic Music*, Stockholm.

Ojanen, Mikko, & Suominen, J. 2005. Erkki Kurenniemen sähkösoittimet. [The Electronic Musical Instruments of Erkki Kurenniemi] *Musiikki*, 35(3), 15–44.

Ojanen, Mikko, Suominen, J., Kallio, T., & Lassfolk, K. 2007. Design Principles and User Interfaces of Erkki Kurenniemi's Electronic Musical Instruments of the 1960's and 1970's. *Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07)*, New York. 88–93.

Oldenziel, Ruth. 2006. Signifying semantics for a history of technology. *Technology and Culture*, 47(3), 477–485.

Oudshoorn, Nelly, & Pinch, T. 2003. How Users and Non-Users Matter. In N. Oudshoorn, & T. Pinch (Eds.), *How Users Matter: The Co-Construction of Users and Technologies*. Cambridge: MIT Press. 1–25.

Paasonen, Susanna. 2013. Slimy Traces: Memory, Technology and the Archive. In M. Mellais (Ed.), *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery. 32–56.

Padilla, Alfonso. 1996. Dialektinen lähestymistapa musiikkitieteessä I. *Musiikki*, 26(2), 223–283.

--- 1997. Dialektinen lähestymistapa musiikkitieteessä II. *Musiikki*, 27(2), 135–194.

Padilla, Alfonso, & Torvinen, J. 2005. Johdanto. In A. Padilla, & J. Torvinen (Eds.), *Musiikin filosofia ja estetiikka: Kirjoituksia taiteen ja populaarin merkityksistä*. Helsinki: Yliopistopaino = Helsinki University Press. 9–21.

Patteson, Thomas. 2016. *Instruments for new music: Sound, technology, and modernism*. Oakland, California: University of California Press.

Peltonen, Matti. 1995. Carlo Ginzburg and the new microhistory. *Suomen Antropologi*, 20(1), 2–11.

--- 2002. Clues, margins, and monads: The micro–macro link in historical research. *History and Theory*, 40(3), 347–359.

Pike, Kenneth Lee. 1967. *Language in Relation to a Unified Theory of the Structure of Human Behavior*. 2nd, rev. ed The Hague: Mouton.

Pinch, Trevor. 2009. Telling Tales about how Concepts Develop: Stories from Ethnographic Encounters with the Moog Synthesizer. In A. Puddephatt, W. Shaffir & S. Kleinknecht (Eds.), *Ethnographies Revisited: Constructing Theory in the Field*. Abingdon: Routledge. 180–194.

Pinch, Trevor, & Bijker, W. 1984. The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science*, 14(3), pp. 399–441.

--- 2012. The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Anniversary Edition Cambridge: The MIT press. pp. 11–44.

Pinch, Trevor, & Trocco, F. 2002a. *Analog Days: The Invention and Impact of the Moog Synthesizer*. Cambridge, Mass: Harvard University Press.

--- 2002b. The Social Construction of the Early Electronic Music Synthesizer. In H. Braun (Ed.), *Music and Technology in the Twentieth Century*. Baltimore: The Johns Hopkins University Press. 67–83.

Rahikainen, Marjatta, & Fellman, S. 2012. Introduction. In S. Fellman, & M. Rahikainen (Eds.), *Historical Knowledge: In Quest of Theory, Method and Evidence*. Newcastle upon Tyne: Cambridge Scholars. 1–3.

Rajewsky, Irina. 2005. Intermediality, intertextuality, and remediation: A literary perspective on intermediality. *Intermédialités: Histoire Et Théorie Des Arts, Des Lettres Et Des Techniques/Intermediality: History and Theory of the Arts, Literature and Technologies*, (6), 43–64.

Rantanen, Miska. 2005. *Love Records 1966–1979: Tarina, taiteilijat, tuotanto*. Espoo: Schildts.

Reimann, Heli. 2015. *Jazz in Soviet Estonia from 1944 to 1953: Meanings, spaces and paradoxes*. [S.l.], [s.n.].

Riikonen, Hannu. 1978. *Osmo Lindemanin elektromusiikkituotannosta: arkkitehtonisia ja toteutusteknisiä periaatteita*. Master's thesis, University of Turku.

Risset, Jean-Claude. 2002. Foreword. In T. Licata (Ed.), *Electroacoustic Music: Analytical Perspectives*. Westport, Connecticut: Greenwood Press. xiii–xvii.

Rogers, Everett M. 1983. *Diffusion of Innovations*. 3rd edition. New York (NY): Free Press.

Rojola, Sanna. 2001. Musiikin ja tutkimuksen tekijät. *Musiikki*, 31(1), 92–96.

Rothbauer, Paulette M. 2008. Triangulation: The Sage Encyclopedia of Qualitative Research Methods. In L. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods*. SAGE Publications, Inc.

Ruohomäki, Jukka. 1994. Switched on: Electronic music under the wing of Yle. *Finnish Music Quarterly*, (1), 9–15.

--- 1998. Pioneers and explorers: Electronic music in Finland 1958–1998. *Finnish Music Quarterly*, (3), 28–35.

--- 2013. Otto Donner ja elektroninen musiikki. *Musiikin Suunta*, 35(3), 6–14.

--- 2020. *Suomalaisen elektroakustisen musiikin historia [käsikirjoitus] / The History of Electroacoustic Music in Finland* [manuscript]. Zenodo. https://doi.org/10.5281/zenodo.3605511.

Samuels, Robert. 2004. *Mahler's Sixth Symphony: A Study in Musical Semiotics*. 1st pbk. edition. Cambridge; New York: Cambridge University Press.

Sandlund, Björn. 2019. *The Early Synth Days: Dataton: The Creative Way of Making Sound*. [S.l.]: Panoramicum Förlag.

Sarjala, Jukka. 2002. *Miten tutkia musiikin historiaa: Johdatus näkökulmiin ja menetelmiin*. Helsinki: Suomalaisen kirjallisuuden seura.

Schaeffer, Myron. 1963. The electronic music studio of the University of Toronto. *Journal of Music Theory*, 7(1), 73–81. doi:10.2307/843022

Schaeffer, Pierre. 2017. *Treatise on Musical Objects: An Essay Across Disciplines*. Oakland, California: University of California Press.

Schedel, Margaret. 2007. The Electronic Music Studio. In N. Collins, & J. d'Escriván (Eds.), *Cambridge Companion to Electronic Music*. Cambridge: Cambridge University Press. 24–38.

Shreffler, Anne C. 2003. Berlin walls: Dahlhaus, Knepler, and ideologies of music history. *The Journal of Musicology*, 20(4), 498–525.

Simoni, Mary. 2006. *Analytical Methods of Electroacoustic Music*. New York: Routledge.

Sirppiniemi, Ano. 2006. Home Studio Aesthetics: Tracking Cultural Processes of Popular Music Production. In E. Pekkilä, D. Neumeyer & R. Littlefield (Eds.), *Music, Meaning and Media. Imatra: International Semiotics Institute*. 174–191.

Sivuoja-Kauppala, Anne, Mantere, M., & Ojala, J. 2013. Esipuhe. *Musiikki*, 43(3–4), 3–4.

Smirnov, Andrej. 2013. *Sound in Z: Experiments in sound and electronic music in early 20th century Russia*. London: Sound and Music.

Städje, Jörgen. 2009. Kärleksmaskinen – synten man spelar med hela kroppen. *IDG.Se*, www.idg.se/2.1085/1.269878/karleksmaskinen---synten-man-spelar-med-hela-kroppen

--- 2012. Andromatic, den automatiska andromedaren. *IDG.Se*, www.idg.se/2.1085/1.445306/andromatic-den-automatiska-andromedaren

--- 2013. Ett slag i luften för vacker musik. *IDG.Se*, www.idg.se/2.1085/1.514246/ett-slag-i-luften-for-vacker-musik

--- 2017. Fötterna på Jorden men huvudet bland molnen. *Teknikaliteter – teknik på djupet*. http://www.teknikaliteter.se/2017/10/24/fotterna-pa-jorden-men-huvudet-bland-molnen/

Sterne, Jonathan. 2003. *The Audible Past: Cultural Origins of Sound Reproduction*. Durham: Duke University Press Books.

Stone, Lawrence. 1979. The Revival of Narrative: Reflections On a New Old History. *Past & Present*, (85), 3–24.

Suominen, Jari. 2013. Erkki Kurenniemi's Electronic Musical Instruments of the 1960s and 1970s. In M. Mellais (Ed.), *Erkki Kurenniemi: A Man from the Future*. Helsinki: Finnish National Gallery. 129–161.

--- 2020. *Erkki Kurenniemi's Integrated Synthesizer – User Manual of the Generator Unit*. Zenodo. https://doi.org/10.5281/zenodo.3600460.

Sutinen, Virve. 2000. "The multidisciplinary path of Dimi-O." *Kiasma Magazine*, 5(16) Retrieved from https://kiasma.fi/kiasma-lehti/16.php?lang=en&id=4

Taanila, Mika. 2002. Laitetestauksia / Just testing the equipment [Sleeve Notes]. In *Erkki Kurenniemi: Äänityksiä/Recordings 1963–1973*. Love Records – LXCD 637.

--- 2007. Seitsemännen taiteen sivullisia – kokeellinen elokuva Suomessa 1933–1985. In K. Väkiparta (Ed.), *Sähkömetsä: Videotaiteen ja kokeellisen elokuvan historiaa Suomessa 1933–1998*. 8–81.

Tagg, P. 2015. NIMiMS: Network for the inclusion of music in music studies: http://nimims.net/.

Talbot, Michael. 2000. The Work-Concept and Composer-Centredness. In M. Talbot (Ed.), *The Musical Work: Reality or Invention?* Liverpool: Liverpool University Press. 168–186.

Tamminen, Tatu. 2017. *Reijo Jyrkiäisen elektroakustinen sävellystuotanto: Kolmen teoksen analyysi*. University of Helsinki.

Tarasti, Eero. 2012. *Semiotics of Classical Music: How Mozart, Brahms and Wagner Talk to Us*. Boston: De Gruyter Mouton.

Taylor, Timothy D. 2001. *Strange Sounds: Music, Technology & Culture*. New York: Routledge.

Taylor, Timothy D., Katz, M., & Gradeja, T. (Eds.). 2012. *Music, Sound, and Technology in America: A Documentary History of Early Phonograph, Cinema, and Radio*. Durham: Duke University Press.

Tenney, James, Pratt, L., Wannamaker, R., Winter, M., & Polansky, L. 2015. *From Scratch: Writings in Music Theory*. Urbana: University of Illinois Press.

Théberge, Paul. 1997. *Any Sound You Can Imagine: Making Music/Consuming Technology*. Hanover (N.H.): Wesleyan University Press.

--- 2001. “Plugged in”: Technology and Popular Music. In S. Frith, W. Straw & J. Street (Eds.), *The Cambridge Companion to Pop and Rock*. Cambridge, UK: Cambridge University Press. 3–25.

--- 2004. The network studio: Historical and technological paths to a new ideal in music making. *Social Studies of Science*, 34(5), 759–781.

Tiekso, Tanja. 2013. *Todellista musiikkia: Kokeellisuuden idea musiikin avantgardemanifesteissa*. Helsinki: Osuuskunta Poesia.

--- 2016. Art has Opened People's Eyes, Music People's Ears and Computers People's Minds: Erkki Kurenniemi on Music and Technology. In T. Ørum, & J. Olsson (Eds.), *A Cultural History of the Avant-Garde in the Nordic Countries, 1950–1975*. Avant-Garde Critical Studies; Volume 32. Leiden: Brill/Rodopi. 401–411.

Tiits, Kalev. 1990a. Erkki Kurenniemi – avantgarden innovaattori. *Musiikkitiede*, 2(2), 37–60.

--- 1990b. *Voluntääriassistentti Kurenniemi ja elektronimusiikin alku yliopistolla*. Master's thesis, University of Helsinki, Department of Musicology.

Toivakka, Svetlana. 2015. *Alma Fohström: Kansainvälinen primadonna*. Helsinki: Suomen musiikkitieteellinen Seura.

Tomlinson, Gary. 1984. The web of culture: A context for musicology. *19th-Century Music*, 7(3), 350–362.

Torvinen, Juha. 2007. *Musiikki ahdistuksen taitona: Filosofinen tutkimus musiikin eksistentiaalis-ontologisesta merkityksestä*. Helsinki: Suomen musiikkitieteellinen seura.

Uimonen, Tanja. 2007. Erkki Salmenhaaran elektroakustiset teokset ja 1960-luvun säveltäjäkuva. [Erkki Salmenhaara’s electroacoustic works and composer image] *Musiikki*, 37(4), 85–99.

Ulmann, Bernd. 2013. *Analog Computing*. München: Oldenbourg Verlag.

van Oost, Elizabeth C.J. 2003. Materialized Gender: How Shavers Configure the Users' Feminity and Masculinity. In N. Oudshoorn, & T. Pinch (Eds.), *How Users Matter: The Co-Construction of Users and Technology*. MIT Press. 193–208.

Voorvelt, Martijn. 2000. New sounds, old technology. *Organised Sound*, 5(2), 67–74.

Väkiparta, K. (Ed.) 2007. *Sähkömetsä: Videotaiteen ja kokeellisen elokuvan historiaa Suomessa 1933–1998*. Helsinki: Valtion taidemuseo.

Wanderley, M. M. 2001. Gestural control of music. *International Workshop Human Supervision and Control in Engineering and Music*, 632–644.

--- 2002. Evaluation of input devices for musical expression: Borrowing tools from HCI. *Computer Music Journal*, 26(3), 62–76.

Weale, R. 2005. Electroacoustic music: English definition. *ElectroAcoustic Resource Site (EARS)*. http://ears.huma-num.fr/305810c2-a85b-4ac1-8b8f-04ee8d096249.html

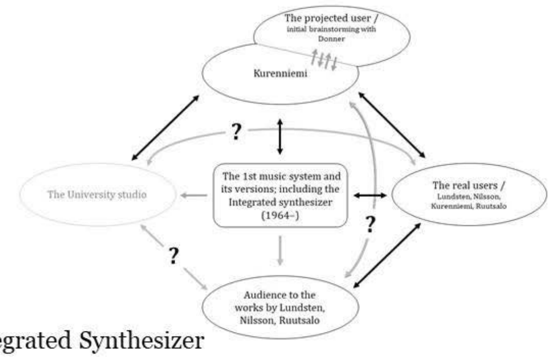
Wiggen, Knut. 1972. The electronic music studio at Stockholm, its development and construction. *Journal of New Music Research*, 1(2), 127–165.

Yli-Annala, Kari. 2007. Pieni jälkiteollinen tuotanto – taiteilijoiden liikkuva kuva Suomessa 1982–1998. In K. Väkiparta (Ed.), *Sähkömetsä: Videotaiteen ja kokeellisen elokuvan historiaa Suomessa 1933–1998*. 138–187.

Zaffiri, Enore. 2007. Selected Writings (1964–2003). In M. Libague (Ed.), *Musica/Tecnologia 1*. Firenze: Firenze University Press e Fondazione Ezio Franceschini. 367–412.

APPENDIX

Appendix 1. Relevant social groups related to the development of Kurenniemi's instruments



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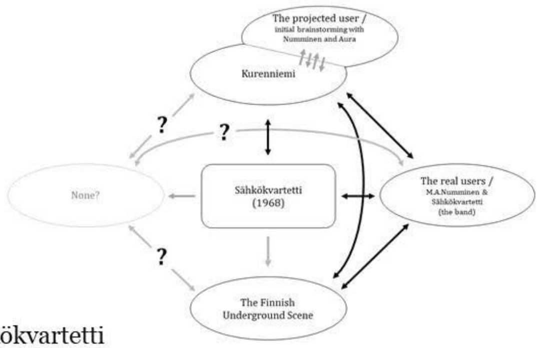

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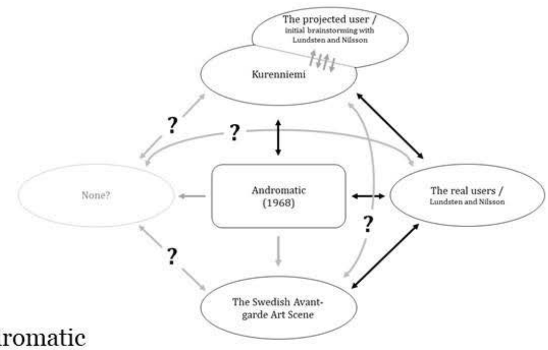

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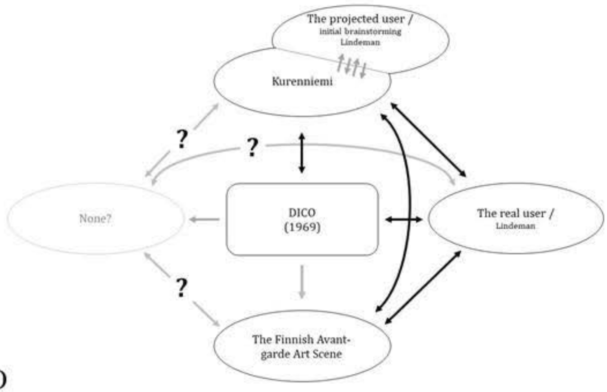

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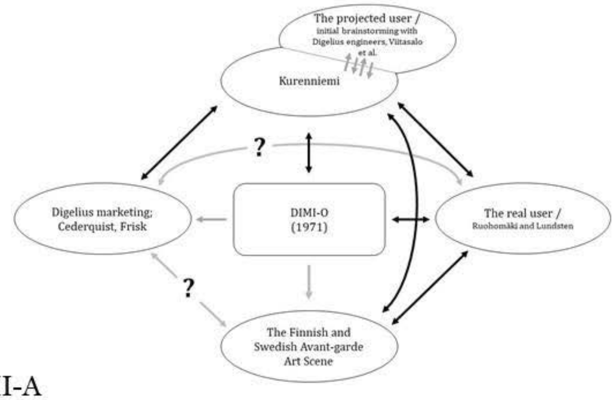

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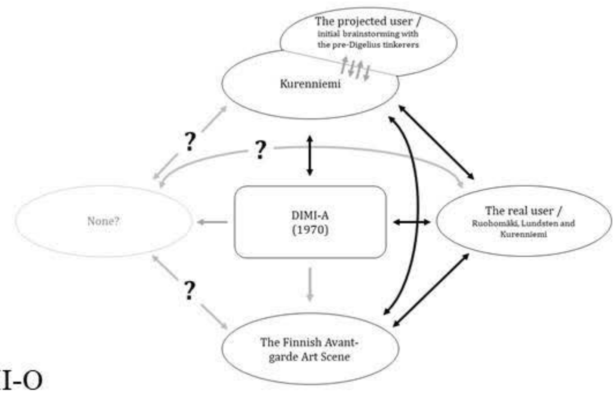

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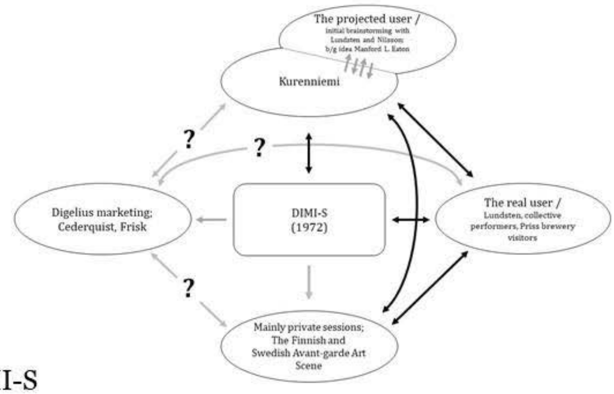

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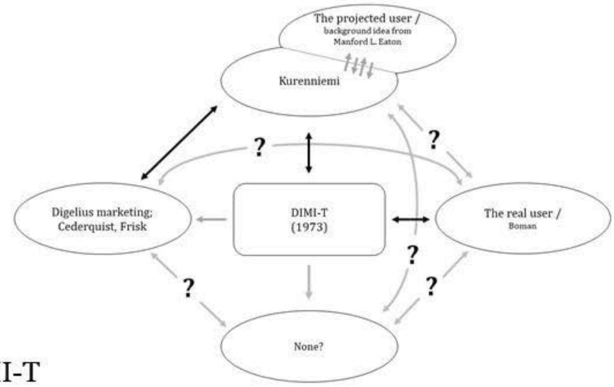

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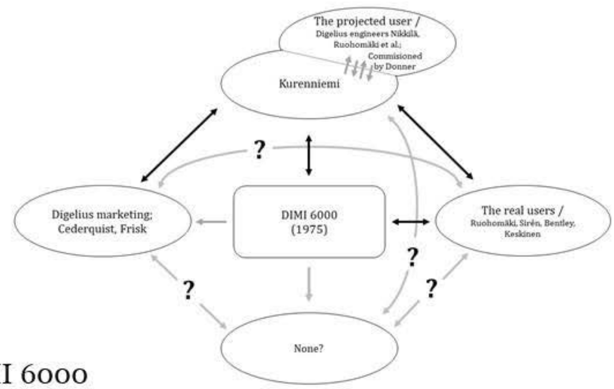

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